Environmental Performance of Agriculture in OECD Countries Since 1990


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Foreword

This is the fourth volume in the OECD series on Environmental Indicators for Agriculture. *Previous volumes dealt with* Concepts and Frameworks *(1997),* Issues and Design *(1999), and* Methods and Results *(2001). Building on the earlier work, this volume is a stocktaking of the environmental performance of agriculture since 1990. It has been prepared in close co-operation between scientific experts, policy makers and the OECD Secretariat during a five-year period. This project is published as two reports, under the title* Environmental Performance of Agriculture since 1990:

- At a Glance – *covering a summary of the main conclusions; and the*
- Main Report – *providing a complete coverage of the project.*

These two reports are supported by a website database that provides all the primary data to the indicators and, for each country, relevant website addresses, national data sets, and a version of the country section in English, French and, where appropriate, the national language.

An important feature of the project was the role played by expert workshops that were able to address indicators in specific areas, such as water, soil organic carbon, farm management, biodiversity and agricultural landscapes in great depth. These workshops brought together experts that were able to review the state of the art in measuring indicators in the respective areas.

This volume is unique in many ways. The co-operative process in preparing the report ensured that as far as possible it brings together in one volume the most up to date and available comparative data on the environmental performance of agriculture in OECD countries. It makes a distinction between those indicators that most closely satisfy the criteria of policy relevance, analytical soundness, measurability and ease of interpretation – in other words those that are most comparable across time and countries – and those that are of importance to only a few countries or group of countries. The volume also provides valuable agri-environmental information on a county-by-country basis and looks at the ways in which countries are using the data to inform their policies.

The report recognizes the formidable problems involved in developing a comparative set of agri-environmental data. In most countries gathering such data is very recent. Methodologies to measure the environmental performance of agriculture are not well-established in all cases. National average data often conceal significant ranges reflecting local site-specific values. A vast amount of data is potentially of interest but the attempt here, even though partial, is to focus on those that are of use to policy makers. And the data are in physical, not common monetary values, so weighing up the overall agri-environmental performance of a country has to be largely qualitative rather than quantitative.

But even given these caveats this report – and the detailed background data and proceedings of the expert meetings available on the OECD website – provides a wealth of data and information for policy makers, researchers and stakeholders wanting to know, explore and analyse agriculture's impact on the environment, whether through modelling efforts, or through simply looking at time or cross-country series data. Moreover, the project has striven to develop broadly agreed methodologies of measurement that can be used at the national, local or farm levels.

The project was carried out under the auspices of the OECD Joint Working Party on Agriculture and the Environment (JWP), of the Committee for Agriculture and the Environment Policy Committee. The original document, entitled Environmental Indicators for Agriculture: Volume 4 *was declassified by the Joint Working Party on Agriculture and the Environment on 15 October 2007.*

The OECD wishes to acknowledge the contribution of member countries in the preparation of this report, especially through expert comment on the text, a series of questionnaires which provided much of the data in the study, and the translation of those country sections not using English or French as their national language (see the OECD website for these translations). A number of countries (Canada, Italy, Japan, Korea, New Zealand, Norway and Switzerland), also hosted Expert Meetings to further develop the indicators in the report (see Section II Background and Scope of the Report*), which were an invaluable source of information. OECD would also like to thank the many experts who helped in variously providing information and preparing and editing the text, especially, Matthew Jackson, Janosch Ondraczek, Richard Pearce, Alina Schick, Scott Smith, BirdLife International, the European Environment Agency, Eurostat (EU Statistical Agency), and the Secretariats of the UN Economic Commission for Europe, UN Environment Programme and the UN Framework Convention on Climate Change.*

The principal author of this report was Kevin Parris, Senior Economist in the Policies and Environment Division of the Trade and Agriculture Directorate, under the overall guidance of Wilfrid Legg, the Head of the Policies and Environment Division. Within the Secretariat, many colleagues from the Trade and Agriculture Directorate and Environment Directorate contributed to the report, in particular, Françoise Bénicourt, Nils-Axel Braathen, Andrea Cattaneo, Dimitris Diakosavvas, Eric Espinasse, Frano Ilicic, Andrzej Kwiecinski, Jussi Lankoski, Myriam Linster, Michèle Patterson, Theresa Poincet, Laetitia Reille, Véronique de Saint-Martin, Noura Takrouri-Jolly and Takeo Tomono. Valuable assistance was also provided by the experts and Secretariat of the OECD Working Group on Pesticides, and also the OECD Translation Division and Public Affairs and Communications Directorate, plus a number of former OECD colleagues, including, Yasuro Funaki, Luis Portugal, Hiroki Sasaki, and Chen Yuong.

Table of Contents

I. Highlights 15
Overall agri-environmental performance 15
Agri-environmental performance in specific areas 16
Caveats and limitations 19
Matching indicator criteria 20

II. Background and Scope of the Report 23
1. Objectives and scope 23
2. Data and information sources 24
3. Progress made since the OECD 2001 Agri-environmental Indicator Report 25
4. Structure of the Report 26
Bibliography 28
Annex II.A1. List of indicators in Chapter 1 29
Annex II.A2. Indicators in Chapter 1 assessed according to the OECD indicator criteria 31

Chapter 1. **OECD Trends of Environmental Conditions related to Agriculture since 1990** 37
1.1. Agricultural production and land 38
1.1.1. Introduction 39
1.1.2. Agricultural production 39
1.1.3. Agricultural land use 40
1.1.4. Linkages between agricultural production and land use 46
Bibliography 47
1.2. Nutrients 48
1.2.1. Nitrogen balance 52
1.2.2. Phosphorus balance 56
1.2.3. Regional (sub-national) nutrient balances 60
Bibliography 62
1.3. Pesticides 63
1.3.1. Pesticide use 63
1.3.2. Pesticide risk indicators 67
Bibliography 74
1.4. Energy 76
Bibliography 83
1.5. Soil 84
Bibliography 90

1.6. Water 92
1.6.1. Water use 93
1.6.2. Water quality 100
Bibliography 108
1.7. Air 109
Background 110
1.7.1. Ammonia emissions, acidification and eutrophication 110
1.7.2. Methyl bromide use and ozone depletion 117
1.7.3. Greenhouse gas emissions and climate change 122
Bibliography 130
1.8. Biodiversity 133
Background 134
1.8.1. Genetic diversity 136
1.8.2. Wild species diversity 146
1.8.3. Ecosystem diversity 148
Bibliography 159
1.9. Farm management 160
1.9.1. Overview of environmental farm management 163
1.9.2. Nutrient management 163
1.9.3. Pest management 168
1.9.4. Soil management 169
1.9.5. Water management 172
1.9.6. Biodiversity management 173
1.9.7. Organic management 174
Bibliography 176

Chapter 2. **OECD Progress in Developing Agri-environmental Indicators** 179
2.1. Introduction 180
2.2. Progress in developing OECD Agri-environmental Indicators 180
2.2.1. Soil: Erosion, biodiversity and soil organic carbon 180
2.2.2. Water: Use and water quality 184
2.2.3. Biodiversity: Genetic, wild species and ecosystem diversity 188
2.2.4. Land: Landscapes and ecosystem functions 192
2.2.5. Farm management 195
2.3. Overall assessment 196
Annex 2.A1. Agri-environmental Indicators of Regional Importance and/or under Development 200
Annex 2.A2. A Qualitative Assessment of the Agri-environmental Indicators included in Annex 2.A1 according to the OECD Indicator Criteria 202
Bibliography 207

Chapter 3. **OECD Country Trends of Environmental Conditions related to Agriculture since 1990** 209
Background to the country sections 210
3.1. Australia 212
3.2. Austria 224
3.3. Belgium 234
3.4. Canada 243

3.5. Czech Republic . . . 256
3.6. Denmark . . . 269
3.7. Finland . . . 284
3.8. France . . . 296
3.9. Germany . . . 305
3.10. Greece . . . 313
3.11. Hungary . . . 324
3.12. Iceland . . . 336
3.13. Ireland . . . 344
3.14. Italy . . . 357
3.15. Japan . . . 366
3.16. Korea . . . 377
3.17. Luxembourg . . . 386
3.18. Mexico . . . 393
3.19. Netherlands . . . 402
3.20. New Zealand . . . 413
3.21. Norway . . . 423
3.22. Poland . . . 433
3.23. Portugal . . . 448
3.24. Slovak Republic . . . 459
3.25. Spain . . . 472
3.26. Sweden . . . 486
3.27. Switzerland . . . 498
3.28. Turkey . . . 507
3.29. United Kingdom . . . 522
3.30. United States . . . 532
3.31. European Union . . . 545

Chapter 4. **Using Agri-environmental Indicators for Policy Analysis** . . . 551

4.1. Policy context to OECD agri-environmental performance . . . 552
4.2. Tracking agri-environmental performance . . . 554
4.2.1. Evolution of Agri-environmental Indicators to track sustainable development . . . 554
4.2.2. Tracking national agri-environmental performance . . . 556
4.2.3. International reporting on environmental conditions in agriculture . . . 559
4.2.4. Non-governmental organisations (NGOs) . . . 561
4.3. Using Agri-environmental Indicators for policy analysis . . . 562
4.3.1. OECD member countries . . . 563
4.3.2. International governmental organisations . . . 565
4.3.3. Research community . . . 567
4.4. Knowledge gaps in using Agri-environmental Indicators . . . 568

Bibliography . . . 571

List of boxes

II.1. OECD Expert Meetings on Agri-environmental Indicators: 2001-04 . . . 25
1.7.1. Towards a net agricultural greenhouse gas balance indicator? . . . 123

1.8.1. Defining agricultural biodiversity 134
2.1. Soil biodiversity in agricultural land 182
2.2. Agricultural livestock pathogens and water pollution 187
2.3. The impact of agriculture on aquatic ecosystems. 188
4.1. Main agri-environmental measures in OECD countries 553
4.2. Selected international and regional environmental agreements relevant to agriculture. 555

List of tables

1.1.1. OECD and world agricultural production 39
1.1.2. OECD and world agricultural exports 40
1.3.1. Germany: Percentage risk indices 70
1.7.1. Total OECD emissions of acidifying pollutants 114
1.7.2. Ammonia emission targets to 2010 under the Convention on Long-range Transboundary Air Pollution. 116
1.7.3. Methyl bromide use and progress in meeting the phase-out schedule under the *Montreal Protocol* 120
1.7.4. Critical Use Exemptions (CUEs) for methyl bromide agreed under the *Montreal Protocol* for 2005 121
1.7.5. Total OECD gross greenhouse gas emissions 124
1.7.6. Main sources and types of gross greenhouse gas emissions 127
1.8.1. Area of transgenic crops for major producing countries 139
1.8.2. Plant genetic resource conservation activities for OECD countries 139
1.8.3. Livestock genetic resource conservation activities for OECD countries. 144
1.8.4. Share of farm woodland in agricultural land area. 157
1.8.5. Share of farm fallow in agricultural land area 157
1.9.1. Countries recording adoption of environmental farm management practices 164
1.9.2. Overview of farmer incentives to adopt environmental farm management practices 166
2.1. Net water balance in a Japanese rice field irrigation system: 2003. 185

List of figures

II.1. The Driving Force-State-Response framework: Coverage of indicators 24
1.1.1. Production, yields and area harvested and future projections for selected commodities and OECD countries 41
1.1.2. Volume of total agricultural production 43
1.1.3. Share of agricultural land use in the national land area 44
1.1.4. Agricultural land area 45
1.1.5. Agricultural production volume index and agricultural land area 46
1.2.1. Main elements in the OECD gross nutrient (nitrogen and phosphorus) balance calculation 50
1.2.2. Gross nitrogen balance estimates 51
1.2.3. Gross nitrogen balances for selected OECD countries 53
1.2.4. Inorganic nitrogen fertilisers and livestock manure nitrogen input in nitrogen balances. 54

1.2.5. Agricultural use of inorganic nitrogen and phosphate fertilisers 54
1.2.6. Contribution of the main sources of nitrogen inputs and outputs in nitrogen balances 56
1.2.7. Nitrogen efficiency based on gross nitrogen balances 57
1.2.8. Gross phosphorus balance estimates 58
1.2.9. Gross phosphorus balance for selected OECD countries 59
1.2.10. Contribution of the main sources of phosphorus inputs and outputs in phosphorus balances 60
1.2.11. Phosphorus efficiency based on phosphorus balances 61
1.2.12. Spatial distribution of nitrogen balances in Canada and Poland 62
1.3.1. Pesticide use in agriculture 65
1.3.2. Pesticide use for selected OECD countries 66
1.3.3. Belgium: Risk for aquatic species due to use of pesticides in arable land, horticulture and outside of agriculture 69
1.3.4. Denmark: The annual trend in frequency of pesticide application 70
1.3.5. The Netherlands: Potential chronic effects scores for aquatic and terrestrial organisms and leaching into groundwater 71
1.3.6. Norway: Trends of health risk, environmental risk and sales of pesticides 72
1.3.7. Sweden: National level pesticide risk indicators and the number of hectare doses 73
1.3.8. United Kingdom (England and Wales): Total area of pesticide applications 74
1.4.1. Simplified energy “model” of an agricultural system 78
1.4.2. Direct on-farm energy consumption 79
1.4.3. Direct on-farm energy consumption for selected OECD countries 80
1.4.4. Agricultural employment and farm machinery use 81
1.4.5. Composition of on-farm energy consumption in the EU15 and the United States 82
1.5.1. Agricultural land area classified as having moderate to severe water erosion risk 87
1.5.2. Trends in agricultural land area classified as having moderate to severe water erosion risk 88
1.5.3. Agricultural land area classified as having moderate to severe wind erosion risk 89
1.6.1. Agricultural water use 95
1.6.2. Share of national water use in annual freshwater resources and share of agricultural water use in national use 96
1.6.3. Irrigated area, irrigation water use and irrigation water application rates 97
1.6.4. Share of agricultural groundwater use in total groundwater use, and total groundwater use in total water use 99
1.6.5. Share of agriculture in total emissions of nitrates and phosphorus in surface water 102
1.6.6. Share of agriculture in total emissions of nitrates and phosphorus in coastal water 103
1.6.7. Share of monitoring sites in agricultural areas exceeding national drinking water limits for nitrates and phosphorus in surface water 104
1.6.8. Share of monitoring sites in agricultural areas exceeding national drinking water limits for nitrates in groundwater 105

1.6.9. Share of monitoring sites in agricultural areas where one or more pesticides are present in surface and groundwater . . . 106
1.6.10. Share of monitoring sites in agricultural areas exceeding national drinking water limits for pesticides in surface water and groundwater . . . 107
1.7.1. Impacts of agriculture on air quality: Multi-pollutants, multi-effects . . . 110
1.7.2. Ammonia emissions from agriculture . . . 112
1.7.3. Emissions of acidifying airborne pollutants for the EU15, US and OECD . . . 113
1.7.4. Agricultural ammonia emission trends for selected OECD countries . . . 114
1.7.5. Share of the main sources of agricultural ammonia emissions in OECD countries . . . 117
1.7.6. Methyl bromide use . . . 119
1.7.7. Global methyl bromide use by major sectors . . . 121
1.7.8. Agricultural gross greenhouse gas emissions . . . 125
1.7.9. Gross agricultural greenhouse gas emissions in carbon dioxide equivalent for selected OECD countries . . . 126
1.7.10. Agricultural production and agricultural greenhouse gas emissions . . . 128
1.7.11. Main sources of methane and nitrous oxide emissions in OECD agriculture . . . 129
1.7.12. Contribution of main sources in agricultural greenhouse gas emissions . . . 130
1.8.1. OECD agri-biodiversity indicators framework . . . 135
1.8.2. Change in the number of plant varieties registered and certified for marketing . . . 137
1.8.3. Change in the share of the one-to-five dominant crop varieties in total marketed crop production . . . 138
1.8.4. Change in the number of livestock breeds registered and certified for marketing . . . 141
1.8.5. Change in the share of the three major livestock breeds in total livestock numbers . . . 142
1.8.6. Total number of cattle, pigs, poultry and sheep in endangered and critical risk status and under conservation programmes . . . 143
1.8.7. Share of selected wild species that use agricultural land as primary habitat . . . 148
1.8.8. Population trends of farmland birds . . . 149
1.8.9. Change in agricultural land use and other uses of land . . . 152
1.8.10. Permanent pasture and arable and permanent cropland . . . 155
1.8.11. Share of arable and permanent cropland, permanent pasture and other agricultural land in total agricultural land area . . . 156
1.8.12. Share of national Important Bird Areas where intensive agricultural practices pose a serious threat or a high impact on the areas' ecological functions . . . 158
1.9.1. OECD farm management indicator framework . . . 162
1.9.2. Share of agricultural land area under nutrient management plans . . . 168
1.9.3. Share of total number of farms under nutrient management plans . . . 169
1.9.4. Share of total number of farms using soil nutrient testing . . . 170
1.9.5. Share of total arable and permanent crop area under integrated pest management . . . 171
1.9.6. Share of arable crop area under soil conservation practices . . . 172
1.9.7. Share of total arable and permanent crop area under all-year vegetative cover . . . 173
1.9.8. Share of irrigated land area using different irrigation technology systems . . . 174

1.9.9. Share of agricultural land area under biodiversity management plans 175
1.9.10. Share of agricultural land area under certified organic farm management 176
2.1. Canadian soil organic carbon stocks in agricultural soils by different classes . . 183
2.2. United States soil organic carbon stocks in agricultural soils by different classes 184
2.3. Agricultural, industrial, and household water charges 186
2.4. National crop varieties that are endangered 189
2.5. National crop varieties that are not at risk. 190
2.6. Edge density of agricultural fields in Finland. 190
2.7. Share of Canadian farmland in various classes of the habitat capacity index. 191
2.8. Cultural landscape features on agricultural land 193
2.9. Water retaining capacity of agriculture 194
2.10. Water retaining capacity for agricultural facilities 195
2.11. Share of farmers participating in agri-environmental education programmes 197
3.1.1. National agri-environmental and economic profile, 2002-04: Australia 212
3.1.2. National agri-environmental performance compared to the OECD average. . . . 220
3.1.3. National Landcare membership. 220
3.1.4. Annual quantities of insecticide and acaricide applied to the cotton crop 220
3.2.1. National agri-environmental and economic profile, 2002-04: Austria 224
3.2.2. National agri-environmental performance compared to the OECD average. . . . 231
3.2.3. Area under non-use of inputs, organic farming and erosion control measures of the ÖPUL agri-environmental programme. 231
3.2.4. Greenhouse gas emissions from agriculture 231
3.3.1. National agri-environmental and economic profile, 2002-04: Belgium 234
3.3.2. National agri-environmental performance compared to the OECD average. . . . 240
3.3.3. Total pesticide use 240
3.3.4. Greenhouse gas emissions and sinks 240
3.4.1. National agri-environmental and economic profile, 2002-04: Canada. 243
3.4.2. National agri-environmental performance compared to the OECD average. . . . 252
3.4.3. Share of cropland in different soil organic carbon change classes. 252
3.4.4. Share of farmland in different wildlife habitat capacity change classes. 252
3.5.1. National agri-environmental and economic profile, 2002-04: Czech Republic . . 256
3.5.2. National agri-environmental performance compared to the OECD average. . . . 265
3.5.3. Share of samples above Czech drinking water standards for nitrates in surface water 265
3.5.4. Monitored numbers of partridge population 265
3.6.1. National agri-environmental and economic profile, 2002-04: Denmark 269
3.6.2. National agri-environmental performance compared to the OECD average. . . . 280
3.6.3. Share of monitoring sites with occurrences of pesticides in groundwater used for drinking 280
3.6.4. Share of meadows and dry grasslands, heath, and bogs and marshes in the total land area 280
3.7.1. National agri-environmental and economic profile, 2002-04: Finland. 284
3.7.2. National agri-environmental performance compared to the OECD average. . . . 292
3.7.3. Nitrogen fluxes in the Paimionjoki river and agricultural nitrogen balances . . . 292

3.7.4. Population trends of Finnish farmland butterflies in three ecological species groups. 292
3.8.1. National agri-environmental and economic profile, 2002-04: France. 296
3.8.2. National agri-environmental performance compared to the OECD average. . . . 302
3.8.3. Trends in key agri-environmental indicators. 302
3.8.4. Trends in key agri-environmental indicators. 302
3.9.1. National agri-environmental and economic profile, 2002-04: Germany 305
3.9.2. National agri-environmental performance compared to the OECD average. . . . 310
3.9.3. Share of the number of farms and Utilised Agricultural Area (UAA) under organic farming. 310
3.9.4. Share of renewable biomass and energy crop area in the total agricultural land area 310
3.10.1. National agri-environmental and economic profile, 2002-04: Greece 313
3.10.2. National agri-environmental performance compared to the OECD average. . . . 321
3.10.3. Irrigated area and irrigation water application rates 321
3.10.4. *Ex situ* accessions of plant landraces, wild and weedy relatives. 321
3.11.1. National agri-environmental and economic profile, 2002-04: Hungary. 324
3.11.2. National agri-environmental performance compared to the OECD average. . . . 333
3.11.3. Agricultural land affected by various classes of water erosion. 333
3.11.4. Support payments for agri-environmental schemes and the number of paid applications. 333
3.12.1. National agri-environmental and economic profile, 2002-04: Iceland 336
3.12.2. National agri-environmental performance compared to the OECD average. . . . 342
3.12.3. Annual afforestation 342
3.12.4. Annual area of wetland restoration. 342
3.13.1. National agri-environmental and economic profile, 2002-04: Ireland 344
3.13.2. National agri-environmental performance compared to the OECD average. . . . 353
3.13.3. River water quality. 353
3.13.4. Population changes for key farmland bird populations 353
3.14.1. National agri-environmental and economic profile, 2002-04: Italy. 357
3.14.2. National agri-environmental performance compared to the OECD average. . . . 363
3.14.3. Actual soil water erosion risk. 363
3.14.4. Regional change in agricultural land area: 1990 to 2000. 363
3.15.1. National agri-environmental and economic profile, 2002-04: Japan 366
3.15.2. National agri-environmental performance compared to the OECD average. . . . 373
3.15.3. National water retaining capacity of agriculture. 373
3.15.4. Share of eco-farmers in the total number of farmers. 373
3.16.1. National agri-environmental and economic profile, 2002-04: Korea 377
3.16.2. National agri-environmental performance compared to the OECD average. . . . 383
3.16.3. Composition of soils 383
3.16.4. National water retaining capacity of agriculture. 383
3.17.1. National agri-environmental and economic profile, 2002-04: Luxembourg 386
3.17.2. National agri-environmental performance compared to the OECD average. . . . 391
3.17.3. Nitrate and phosphorus concentration in river sampling stations. 391
3.17.4. Agricultural land under agri-environmental schemes 391
3.18.1. National agri-environmental and economic profile, 2002-04: Mexico 393
3.18.2. National agri-environmental performance compared to the OECD average. . . . 399

3.18.3. Trends in key agri-environmental indicators 399
3.18.4. Trends in key agri-environmental indicators 399
3.19.1. National agri-environmental and economic profile, 2002-04: Netherlands 402
3.19.2. National agri-environmental performance compared to the OECD average 409
3.19.3. Annual mean concentrations of nitrogen and phosphorus in surface water of rural and agricultural water catchments 409
3.19.4. Farmland bird populations 409
3.20.1. National agri-environmental and economic profile, 2002-04: New Zealand 413
3.20.2. National agri-environmental performance compared to the OECD average 420
3.20.3. Sectoral use of pesticides: 2004 420
3.20.4. Dairy cattle enteric methane emissions per litre of milk 420
3.21.1. National agri-environmental and economic profile, 2002-04: Norway 423
3.21.2. National agri-environmental performance compared to the OECD average 430
3.21.3. National sales of pesticides 430
3.21.4. Net change in agricultural land for five counties 430
3.22.1. National agri-environmental and economic profile, 2002-04: Poland 433
3.22.2. National agri-environmental performance compared to the OECD average 444
3.22.3. Agriculture and forest land at risk to erosion 444
3.22.4. Index of population trends of farmland birds 444
3.23.1. National agri-environmental and economic profile, 2002-04: Portugal 448
3.23.2. National agri-environmental performance compared to the OECD average 456
3.23.3. Numbers of local breeds under *in situ* conservation programmes: 2006 456
3.23.4. Relation between land use and Designated Nature Conservation Areas (DNCA): 2004 456
3.24.1. National agri-environmental and economic profile, 2002-04: Slovak Republic . . 459
3.24.2. National agri-environmental performance compared to the OECD average 468
3.24.3. Agricultural methane (CH_4) and nitrous oxide (N_2O) emissions 468
3.24.4. Share of agricultural land under different types of protected areas: 2003 468
3.25.1. National agri-environmental and economic profile, 2002-04: Spain 472
3.25.2. National agri-environmental performance compared to the OECD average 482
3.25.3. Area of organic farming 482
3.25.4. Share of Dehesa area in total land area for five regions 482
3.26.1. National agri-environmental and economic profile, 2002-04: Sweden 486
3.26.2. National agri-environmental performance compared to the OECD average 494
3.26.3. Losses of nutrients from arable areas and the root zone 494
3.26.4. Cultural features on arable land 494
3.27.1. National agri-environmental and economic profile, 2002-04: Switzerland 498
3.27.2. National agri-environmental performance compared to the OECD average 504
3.27.3. Support for agricultural semi-natural habitats 504
3.27.4. Input/output efficiency of nitrogen, phosphorous and energy in agriculture . . . 504
3.28.1. National agri-environmental and economic profile, 2002-04: Turkey 507
3.28.2. National agri-environmental performance compared to the OECD average 518
3.28.3. Trends in key agri-environmental indicators 518
3.28.4. Trends in key agri-environmental indicators 518
3.29.1. National agri-environmental and economic profile, 2002-04: United Kingdom 522
3.29.2. National agri-environmental performance compared to the OECD average 528

3.29.3. Agri-environmental trends 528
3.29.4. Greenhouse gas emission trends and projections. 528
3.30.1. National agri-environmental and economic profile, 2002-04: United States. . . . 532
3.30.2. National agri-environmental performance compared to the OECD average. . . . 540
3.30.3. Soil erosion on cropland 540
3.30.4. Change in palustrine and estuarine wetlands on non-federal land and water area 540
3.31.1. National agri-environmental and economic profile, 2002-04: European Union (15) 545
3.31.2. EU15 agri-environmental performance compared to the OECD average 548
3.31.3. Agri-environmental trends, EU15 548
3.31.4. Agri-environmental trends, EU15 548

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Environmental Performance of Agriculture in OECD Countries since 1990
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I. Highlights

Agriculture can have significant impacts on the environment as it uses on average over 40% of water and land resources in OECD countries. The impacts occur on and off farm, including both pollution and degradation of soil, water and air, as well as the provision of ecological goods and services, such as biodiversity and providing a sink for greenhouse gases.

Most OECD countries are tracking the environmental performance of agriculture, which is informing policy makers and society on the state and trends in agri-environmental conditions, and can provide a valuable aid to policy analysis (Chapter 4). As countries are increasingly using a wide range of policy measures to address agri-environmental issues, indicators provide crucial information to monitor and analyse the effects of those policies on the environment. They are also enriching the understanding and analysis of the environmental effects of possible future policy scenarios and agricultural projections.

This report provides the latest and most comprehensive data across OECD countries on the environmental performance of agriculture since 1990. A set of agri-environmental indicators (Annex II.A1, Section II) has been developed through several specific theme-focused workshops involving OECD country analysts and scientific experts, complemented with thorough reviews of the literature. The OECD's Driving Force-State-Response model (DSR) is the organising framework for developing the indicators.

These Highlights focus on those indicators most closely satisfying the established indicator criteria of policy relevance, analytical soundness, measurability and ease of interpretation (Annex II.A2, Section II). The *Highlights* are followed in Section II by the *Background and Scope to the Report*, with this section providing a list of the agricultural indicators (Annex II.A1) used to examine the environmental performance of OECD agriculture since 1990 (Chapter 1), while the environmental trend of agriculture in each of the 30 OECD member countries and the EU15 is covered in Chapter 3. The indicators relate to agri-environmental issues faced by most OECD countries and are based on the best available science and data available for a spectrum of countries that are representative of the OECD membership.

Indicators are at various stages of development in OECD countries. The OECD agri-environmental indicators project has been undertaken in close co-operation with OECD member countries. This has been mutually beneficial and great efforts have been made to establish the research, define the methodologies and provide the data to develop the indicators. While this often resulted in high costs for countries, it has produced a set of tools that are essential to track and evaluate environmental performance and policy effectiveness.

Overall agri-environmental performance

Overall the environmental performance of agriculture across the OECD has improved, but with significant variations within countries. The main factors contributing to these developments have been the reactions by policy makers, farmers and agro-industry to public concerns on the state of the environment.

But in the future there are likely to be continuing concerns with the availability and quality of water, preservation of biodiversity, and the health of soils in some countries and localities. While this report does not examine the effects on farming of pollution from non-agricultural sources, the damage from invasive species, competition for land and water resources from other uses, or the impact of climate change, for example, these factors need to be borne in mind when assessing the environmental performance of agriculture.

Agriculture's contribution to national income and employment in OECD countries overall is small. However, from 1990-92 to 2002-04 the volume of OECD agricultural production rose by over 4%, and further growth is projected over the next decade, although for a half of OECD countries the volume of agricultural production changed little or decreased over this period. With a decrease in the total OECD area farmed (–4%) and employment (–15%), higher productivity is being achieved by genetic improvements, better input management (nutrients, pesticides, water and energy), technological innovations, and changes in farm structures. Farmland is being converted mainly to use for forestry and urbanisation (housing and transport networks). But for a few OECD countries the area farmed has increased over the past 15 years (Belgium, Luxembourg, Mexico, Norway, Turkey).

Agriculture's use of inputs is a major driving force leading to pressure on the environment. In OECD countries over the period 1990-92 to 2002-04 inorganic phosphate fertiliser (–10%) and pesticide use (–5%) have declined, but has increased for inorganic nitrogen fertiliser (3%), water (2%), and on-farm direct energy consumption (3%). With farm production increasing more rapidly than the use of most inputs, this suggests that input efficiency has improved and as a consequence pressure on the environment has eased. For the majority of OECD countries use of these inputs has decreased since 1990, although for a few overall input use is rising (Australia, Canada, Greece, Ireland, New Zealand, Portugal, Spain and Turkey).

Policies play a central role in agriculture's impact on the environment. Support to OECD farmers (as measured by the OECD's Producer Support Estimate indicator) currently accounts for about 30% of total farm receipts, most of which is still linked to production (Chapters 3 and 4). Production linked support encourages the higher use of inputs and maintenance of land in agriculture, often increasing pressure on many environmental parameters than would be the case in the absence of this form of support. But there has been a shift away from production linked policies and greater use of specific measures intended to improve the environment. National and international environmental policies are also exerting a growing influence on the environmental impact of farming, especially concerning water quality and availability, ammonia emissions, climate change, and biodiversity.

Ultimately, it is the actions and practices of farmers that determine environmental performance. Reacting to public concerns and policies, farmers have become increasingly aware of the effects of their actions on the environment and there has been a marked improvement in farm management practices based on better scientific and technical knowledge, and investments in environmentally beneficial goods and services, drawing on developments and incentives in the agri-food chain.

Agri-environmental performance in specific areas

The overall OECD decrease in agricultural nutrient balance surpluses (*i.e.* the balance between nitrogen and phosphorus *inputs*, largely fertilisers and livestock manure, and *outputs*, the uptake of nutrients by crops and pasture) has contributed to reduced environmental pressures on soil, water and air. Less than a third of OECD countries,

however, registered an increase in nutrient surpluses during 1990 to 2004. Most countries that have recorded large decreases in nutrient surpluses are mainly those with the highest intensity of nutrient use (expressed as kg nutrient surplus/hectare of farmland), indicating there is still room for improvement. Rising or large nitrogen surpluses are commonly a result of the intensification of livestock production, since the growth in the use of inorganic nitrogen fertilisers has been limited in most countries. Due to the accumulation of phosphorus in farmed soils and its slow transport time, concentrations in water could continue to rise, even while phosphorus surpluses are diminishing.

There has been a declining OECD trend in pesticide use, but for a third of OECD member countries pesticide use rose between 1990-92 and 2001-03 (active ingredients). Although evidence on the environmental effects associated with pesticide use is not widespread across OECD countries, existing data suggest a link between a decrease (increase) in pesticide use and decreasing (increasing) harmful effects. Although pesticide use has increased in some countries, pesticides have changed over time and many of them are today less environmentally harmful, but the persistence in the environment of some older pesticides (*e.g.* DDT, atrazine and derivatives) remains a concern, although these products are now banned in many countries.

OECD wide direct on-farm energy consumption rose by 3% between 1990-92 and 2002-04 compared to an increase of 19% for all sectors, but nearly a half of the member countries reduced their energy consumption. For countries where on-farm energy consumption has increased this has been mainly due to higher production, continued expansion of mechanisation and increasing machinery power. ***Energy subsidies, mainly for on-farm fuel use, are widespread*** but a disincentive to reduce energy consumption and use energy resources more efficiently with the potential benefit of lowering greenhouse gas emissions.

Overall there has been some improvement, or at least stability in soil erosion, with a reduction in areas of moderate to severe erosion risk. This is associated with the growing adoption of soil conservation practices, such as low or no soil tillage, the requirement in some OECD countries to maintain green cover during winter, and a reduction in the cultivation of fragile soils. But for almost a third of OECD countries over 20% of their agricultural land is classified as having moderate to severe water erosion risk (over 11 tonnes/hectare/year), although this applies to only three countries for wind erosion risk. The costs from off-farm soil erosion are high in some regions, involving costs for treating drinking water, dredging rivers, and improving aquatic ecosystems.

OECD wide agricultural water use overall has grown more rapidly (2%) than for total water use (0%) over the period 1990-92 to 2001-03, mainly driven by a 6% expansion in the total OECD area irrigated. For over a third of OECD countries, however, water use decreased. Over-exploitation of water resources in certain areas is damaging ecosystems by reducing water flows in rivers and to wetlands. Groundwater use for irrigation is above recharge rates in some regions, which is also undermining the economic viability of farming in affected areas. ***Government support for irrigation is widespread,*** exacerbated by energy subsidies for groundwater pumping in some countries, and can act as a disincentive to efficient water use. This is also linked to a low uptake of water efficient irrigation technologies and poor maintenance of irrigation infrastructure leading to water wastage and leakages in many OECD countries. Even so, overall the OECD average water application rate per hectare irrigated declined by 9% between 1990-92 and 2001-03, notably decreasing in Australia, but also to a lesser extent in Italy, Mexico, and the United States, but increasing for others, for example, in Greece, Portugal and Turkey.

Water pollution from agriculture in OECD countries has on average declined slightly since 1990, linked to reductions in nutrient surpluses and pesticide use. But nearly a half of OECD countries record that nutrient and pesticide concentrations in surface and groundwater monitoring sites in agricultural areas exceed national drinking water recommended limits. Pollution of groundwater is of particular concern as natural recovery rates from pollution can take many decades. Moreover, absolute pollutant levels are significant in many regions, and in some areas farming's share in nutrient water pollution has become more important as other pollution sources (*e.g.* industry, urban waste) have decreased more rapidly than for farming. Costs of treating drinking water to remove nutrients and pesticides and to improve aquatic environments are significant in many countries.

***Agricultural air pollutants* accounted** for a relatively small share of total OECD acidifying emissions (2%), use of ozone depleting substances (8%), and greenhouse gases (8%) (2002-04):

- ***Acidifying emissions*** – agricultural *ammonia emissions* (from livestock and fertilisers) rose by 1% between 1990-92 and 2001-03, compared to a reduction in acidifying emissions from other sources. Some countries will need to reduce ammonia emissions further if they are to meet the 2010 targets agreed under the *Gothenburg Protocol*. But for more than two-thirds of OECD countries agricultural ammonia emissions declined.
- ***Ozone depletion*** – OECD countries have met the 70% reduction target for *methyl bromide* use (an ozone depleting substance) between 1991 and 2003 under the *Montreal Protocol*, which was due to have been completely phased-out by 2005. Critical Use Exemptions (CUEs) have been agreed for 2005 under the *Montreal Protocol* to give farmers and other users additional time to develop substitutes. Granting CUEs may impede the effectiveness of achieving reduction targets and acting as a disincentive to seek alternatives.
- ***Climate change*** – aggregate OECD greenhouse gases (GHGs) from agriculture decreased by 3% from the *Kyoto Protocol* base period (1990-92), compared to an increase in total OECD economy-wide GHG emissions of 8% up to 2002-04. But for a few countries agricultural GHG emissions increased over the past 15 years, by over 10% for Canada, New Zealand and Spain. Moreover, although information is currently limited, agriculture can also help to lower greenhouse gas emissions through increasing the soil carbon sink capacity of farmed soils, and expanding biomass supplies as a feedstock for renewable energy and raw material production.

Identifying agricultural impacts on biodiversity is complex, and also made difficult as relatively few countries regularly monitor agri-biodiversity. Biodiversity, as identified under the *Convention of Biological Diversity*, involves three levels, including genetic, wild species and ecosystem diversity:

- ***Genetic diversity of crop varieties and livestock breeds used in farming is increasing in certain OECD countries***, probably due to farmers' business strategies associated with diversification, niche market development, and agri-environmental policies. However, the extent to which this is improving the environmental resilience of farming systems and lowering disease risks is unclear.
- ***Wild species richness and abundance linked to agriculture has declined***, which is of concern as in many countries farmland is a major primary habitat for flora and fauna. More specifically, in total OECD *farmland bird populations* fell over the past decade (for just over half of the OECD countries that monitor farmland birds), but in some countries populations have shown signs of recovery more recently.

- ***Ecosystem diversity linked to agriculture has deteriorated*** with adverse impacts on wild species mainly due to: the deterioration in the quality of farmland habitats; nutrient and pesticide pollution; reduced water flows; the clearance of native vegetation; and, in some areas, abandonment of farmland with high nature or landscape value to overgrowth and the conversion of farmland to other uses, such as forestry. But with the reduction in agricultural water and air pollution in many OECD countries and an increase in farmland under wildlife conservation schemes, this is helping to ease pressure on wild species.

A growing number of farmers are adopting environmental farm management practices in response to changes in the state of the environment. But only a third to a half of OECD member countries are regularly monitoring changes in environmental farm management practices. Increased uptake of these practices is the result of incentives provided through government payments and regulations, and voluntary private-led initiatives, often promoted by food processors and retailers, local markets or by decisions of individual farmers themselves. There are relatively higher uptakes by farmers for environmental nutrient and soil management practices compared to those for pest, water and biodiversity management practices. Policies and private initiatives have led to the rapid expansion of the area under certified organic farming in many countries, although by 2002-04 it accounted for less than 2% of the total OECD agricultural land area, but over 6% for a few countries (Austria, Denmark, Finland, Italy, Switzerland).

Caveats and limitations

The indicators in this report provide a basis on which policy makers can have a picture of overall trends that may require action on their part, and as a tool for analysing the impact of agricultural activities and policies on the environment. However, given the complexity of calculating a wide range of indicators, across 30 OECD countries, and covering developments since 1990, it is inevitable that there are caveats and limitations when making comparisons over time and across countries, including (Annex II.A2, Section II):

- ***Definitions and methodologies for calculating indicators*** are standardised in most cases but not all, in particular those for biodiversity and farm management. For some indicators, such as greenhouse gas emissions (GHGs), the OECD and the UNFCCC are working toward further improvement, such as by incorporating agricultural carbon sequestration into a net GHG balance.
- ***Data availability, quality and comparability*** are as far as possible complete, consistent and harmonised across the various indicators. But deficiencies remain, such as the absence of data series (*e.g.* pesticide risks, biodiversity), variability in data coverage (*e.g.* pesticide use and energy consumption), and differences related to how the data was collected (*e.g.* surveys for farm management, census for land use, and field surveys and models for water use) (Annex II.A2, Section II). ***Spatial aggregation*** of indicators is given at the national level, but for certain indicators (*e.g.* water quality) this can mask significant variations at the regional level, although where available the report provides information on regionally disaggregated data.
- ***Trends and ranges in indicators*** rather than absolute levels are important for comparative purposes across countries for many indicator areas, especially as local site specific conditions can vary considerably within and across countries. But absolute levels are of significance where: limits are defined by governments on the basis of scientific evidence

(*e.g.* nitrates in water); targets agreed under national and international agreements (*e.g.* ammonia emissions); or where the contribution to global pollution is important (*e.g.* greenhouse gases).

- ***Agriculture's contribution to specific environmental impacts*** is sometimes difficult to isolate, especially for areas such as soil and water quality, where the impact of other economic activities is important (*e.g.* forestry) or the "natural" state of the environment itself contributes to pollutant loadings (*e.g.* water may contain high levels of naturally occurring salts), or invasive species may have upset the "natural" state of biodiversity.
- ***Environmental improvement or deterioration*** is in most cases clearly revealed by the direction of change in the indicators (*e.g.* soil erosion, greenhouses gases), but in some cases changes can be ambiguous. For example, changes in farm practices, such as the greater uptake of conservation or minimum till can lower soil erosion rates and reduce energy consumption (from less ploughing), but at the same time may result in an increase in the use of herbicides (to combat weeds).
- ***Baselines, threshold levels or targets for indicators*** are generally not used to assess indicator trends in the report as these may vary between countries and regions due to difference in environmental and climatic conditions, as well as national regulations. But for some indicators threshold levels are used to assess indicator change (*e.g.* drinking water standards) or internationally agreed targets compared against indicators trends (*e.g.* ammonia emissions and methyl bromide use).

Matching indicator criteria

The indicators developed by the OECD need to satisfy a set of criteria of policy relevance, analytical soundness (scientific rigour), measurability and ease of interpretation, to aid comparability over time and across countries. How far do the OECD agri-environmental indicators match up to the established criteria?

- ***Policy relevance*** – a key requirement of the indicators is that they adequately track developments that are of public concern, and are able to reflect changes in policies and farmer actions. Areas where indicators do not perform well in this regard include, for example, the relationship between farm pesticides and water pollution, and the impacts of farming on ecosystems. The number of OECD countries covered by each indicator is summarised in Annex II.A2, Section II. In most cases country coverage is representative of the OECD membership, although notably country coverage of indicators related to agriculture's impact on water quality and biodiversity is more limited than for other indicators. The contribution of the agricultural sector in environmental effects is also shown in Annex II.A2, Section II, where relevant, highlighting the importance of agriculture in the economy, notably in its use of land and water resources.
- ***Analytical soundness*** – the scientific understanding of biophysical relationships and their interaction with farming activities is variable (Annex II.A2, Section II). Nutrient balances and soil erosion indicators are based on robust scientific understanding of nitrogen cycles and soil transport and fate models. But in a number of other areas there is still incomplete knowledge. For example, the biophysical links between farming activities and biodiversity, including soil biodiversity, are not fully understood, while knowledge of the pathways and extent of agricultural pollutants into groundwater is poor. The variability in the analytical soundness of the indicators is also reflected in differences in the certainty between indicator estimates.

- ***Measurability*** – the measurability of indicators depends on good data coverage and quality, which varies across countries (Annex II.A2, Section II). While certain data are regularly collected across most countries through agricultural census (*e.g.* land area), surveys are also frequently used to collect environmental data (such as farm management indicators), but country coverage is typically patchy. Countries often differ in the definitions of data coverage. For example, in some countries, pesticide and energy data only include agriculture, but for other countries they also cover other activities, such as forestry. Governments are usually the main institution that collect data to calculate indicators, but OECD has also drawn on other international organisations (*e.g.* UNFCCC for greenhouse gases) and non-governmental organisations (*e.g.* BirdLife International for trends in farmland bird populations). In some countries data are available only nationally, in others sub-national data are also available.
- ***Interpretation*** – in most cases the indicators are easy to interpret by policy makers and the wider public, but some indicators remain difficult to understand without specialist knowledge, such as indicators of agricultural genetic diversity and pesticide risk indexes (Annex II.A2, Section II). But the interpretation of indicator results needs to be undertaken with great care and in some cases cannot be compared between countries. OECD average trends can mask wide differences between countries, while national indicator trends can also hide large regional and local variations, as is especially the case for nutrient surpluses and water pollution. There are also marked disparities in absolute indicator levels between countries, notably nutrient surpluses, the use of pesticides, energy and water use, and air emissions. It is also very difficult to make an overall assessment of the trends in the environmental performance of a country given the absence of a common measure (*e.g.* monetary unit) to weigh the changes in physical units of a wide range of indicators.

The caveats to the interpretation of the indicators in this report need to be viewed in a broader context, as in many cases they also apply to other indicators regularly used by policy makers. For example, there can be wide variations around national averages of socio-economic indicators (*e.g.* retail price index), and methodological and data deficiency problems are not uncommon (*e.g.* wealth distribution).

Work on establishing agri-environmental indicators is relatively recent compared with the much longer history of developing economic indicators, such as Gross Domestic Product. Measuring the linkages between the biophysical environment and human activities through indicators is more complex than monitoring trends in socio-economic phenomena, given that many agri-environmental effects do not benefit from having market (monetary) valuations, and are not even easily measured in physical terms (*e.g.* biodiversity).

This report has also examined other indicators (Chapter 2). Some of these indicators relate to environmental issues of widespread interest across countries, but neither the data nor the methodology are sufficiently advanced to develop cross-country time series, such as the case for a soil organic carbon indicator. Moreover, other indicators are policy relevant to some OECD countries, such as those concerning cultural landscapes in agricultural regions and the water retaining capacity of farming systems.

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II. Background and Scope of the Report

1. Objectives and scope

This publication is the latest in a series of OECD reports, *Environmental Indicators for Agriculture*, first published in 1997 (OECD, 1997; 1999; 2001). ***A key objective for OECD work on agriculture and the environment is to use agri-environmental indicators (AEIs) specifically as a tool to assist policy makers*** in the design, monitoring and evaluation of policies. This work involves:

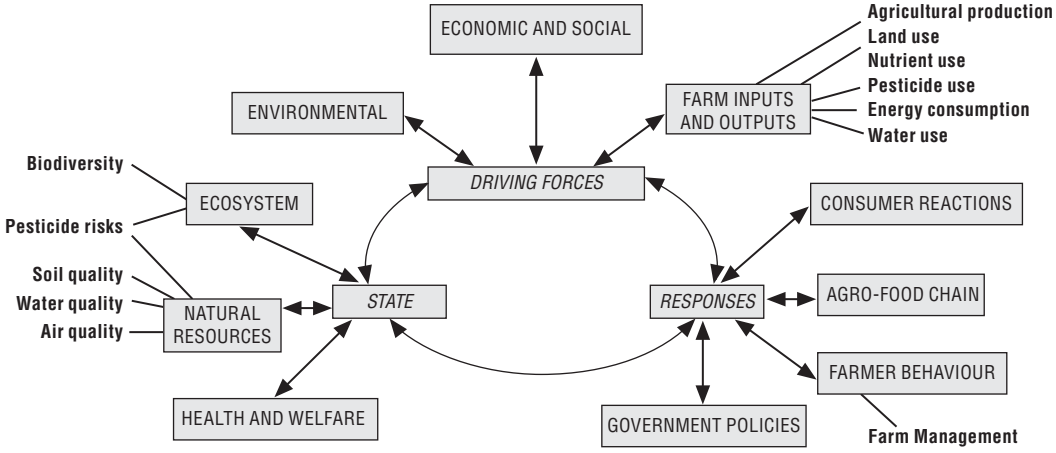
1. describing the current state and trends of environmental conditions in agriculture that may require policy responses (*i.e.* establishing baseline information for policy analysis);
2. highlighting where "hot spots" or new challenges are emerging;
3. providing a tool to help in explaining the causes and effects of changes in the environmental conditions of agriculture, especially the role that policy has to play relative to other drivers in agricultural systems, for example changes in technology and consumer preferences;
4. comparing trends in performance across time and between countries, especially to assist policy makers in meeting environmental targets, threshold levels and standards where these have been established by governments or international agreements; and
5. using indicators in modeling policy scenarios (*e.g.* the environmental effects of different policy instruments and mixes), and projecting future trends.

The OECD set of AEIs, which are part of a broader national and international effort to develop indicators (Chapter 4), can ***help in answering a broad range of policy questions***, including:

- What is the impact of agriculture on the environment, so that policy makers can target the most important impacts?
- What are the environmental impacts of changing support to the agriculture sector?
- What are the environmental impacts of different agricultural policy instruments, such as price support, area or headage payments, or direct income payments?
- What might be the environmental impacts of extending current policies and farming practices into the future?
- What are the economic implications for the agricultural sector of meeting environmental targets, such as those set out in international agreements?

The OECD's Driving Force-State-Response (DSR) model provides the organising framework for this report (Figure II.1). There are a wide range of economic, social and environmental factors that determine the environmental outcomes from farming, as illustrated by the DSR model (OECD, 1997). The scope of the report seeks to explore the environmental pathways outlined in the DSR model across OECD countries over the period 1990-2004 for primary agriculture, but not the whole of the agri-food chain.

Figure II.1. **The Driving Force-State-Response framework: Coverage of indicators**



Source: Adapted from OECD (1997).

Not all the DSR pathways identified in Figure II.1 are covered in the report. In particular, the influence of policies, market developments, and structural changes in the industry on the environmental performance of agriculture are outside the scope of the report (OECD, 2004a). Moreover, the report does not examine the impacts of changes in environmental conditions on agriculture (*e.g.* native and non-native wild species, droughts and floods, climate change); the impact of genetically modified organisms on the environment; nor the human health and welfare consequences of using farm chemicals. The report also does not repeat the discussion, contained in previous volumes in this series, on the concepts behind the indicators or the detail of the DSR framework (see OECD, 1997, 1999 and 2001).

The DSR indicator areas examined in the *Highlights* (Section I) and Chapter 1 are bolded in Figure II.1 (Annex II.A1).

2. Data and information sources

The main sources of data, indicator methodologies, and country information used in this report were the:

1. OECD member country responses to three unpublished ***Agri-environmental Indicator Questionnaires*** provided to the Secretariat between October 2003 to June 2006;
2. ***seven OECD Expert Meetings*** hosted by member countries on specific agri-environmental indicator areas, which provided valuable guidance for the selection and definition of indicators as well as detailed data and information from country case studies presented at the Meetings (Box II.1);
3. ***OECD regular work on collecting environmental data*** (see OECD 2004b; 2006). and the development of pesticide risk indicators in the OECD Working Group on Pesticides (see the OECD Working Group on Pesticides website: *www.oecd.org/ehs*);
4. ***information and data obtained from external sources*** (Annex II.A2), including international governmental organisations, such as FAO, Eurostat, the Secretariats to various international environmental agreements (*e.g. Kyoto Protocol*, *Gothenburg Protocol* and *Montreal Protocol*), and non-governmental organisations, such as BirdLife International; and the

Box II.1. **OECD Expert Meetings on Agri-environmental Indicators: 2001-04**

- **Agriculture and Biodiversity: Developing Indicators for Policy Analysis.** Swiss Federal Research Station for Agroecology and Agriculture, Zurich-Reckenholtz, Switzerland, November, 2001.
- **Agricultural Impacts on Landscapes: Developing Indicators for Policy Analysis.** Norwegian Institute of Land Inventory (NIJOS) on behalf of the Norwegian Ministry of Agriculture, Oslo, Norway, October, 2002.
- **Soil Organic Carbon and Agriculture: Developing Indicators for Policy Analyses.** Agriculture and Agri-Food Canada, Ottawa, Canada, October, 2002.
- **Agricultural Impacts on Soil Erosion and Soil Biodiversity: Developing Indicators for Policy Analysis.** Italian Ministry of Agricultural and Forestry Policies, the Ministry for the Environment and Territory, and the National Institute of Agricultural Economics, Rome, Italy, March, 2003.
- **Agriculture and Land Conservation: Developing Indicators for Policy Analysis.** Japanese Ministry of Agriculture, Forestry and Fisheries, Kyoto, Japan, May, 2003.
- **Agricultural Impacts on Water Use and Water Quality: Developing Indicators for Policy Analysis.** Korean Republic Ministry of Agriculture and Forestry and Korean Rural Development Administration, Gyeongju, the Republic of Korea, October, 2003.
- **Farm Management and the Environment: Developing Indicators for Policy Analysis.** New Zealand Ministry of Agriculture and Forestry, Palmerston North, New Zealand, March, 2004.

Source: The Proceedings of these Expert Meetings can be freely downloaded from the OECD website at: *www.oecd.org/tad/env/indicators*.

5. ***extensive review of the literature, databases and websites***, especially for the information needed to prepare the country-by-country environmental performance assessments provided in Chapter 3.

3. Progress made since the OECD 2001 Agri-environmental Indicator Report

OECD work on AEIs has led to considerable progress in both the identification and specification of the characteristics of policy-relevant indicators. It has also calculated indicators in a number of areas, which now have gained an international reputation as providing a benchmark in environmental monitoring for the agricultural sector. ***Progress has been made in developing indicators that, as far as possible, meet the OECD criteria of***:

- ***policy relevance*** – addressing the key environmental issues faced by governments and other stakeholders in the agriculture sector;
- ***analytical soundness*** – based on the best available scientific knowledge, which recognises that this is constantly evolving;
- ***measurability*** – availability of current or planned data which is cost effective to collect; and,
- ***ease of interpretation*** – such that the indicators communicate essential information to policy makers and the wider public in ways that are unambiguous and easy to understand.

Policy relevance. In this report the AEIs have been identified in terms of two main groups with respect to their policy relevance across OECD countries, namely those most closely related to agri-environmental issues:

1. faced by most OECD countries, which are based on the best available science and data available for a representative group of countries (Annex II.A1 and Annex II.A2); and, those
2. that are only policy relevant to some OECD countries (*e.g.* indicators of cultural landscapes in farming regions and the water retaining capacity of farming systems) (Annex 2.A1, Chapter 2).

Analytical soundness. The analytical basis of the AEIs has been greatly enhanced compared to the 2001 report due to the:

1. advances made in the OECD Expert Meetings (Box II.1), which focused effort on those indicators where scientific knowledge of the indicators was lacking, the calculation methodologies are weak, or where existing indicators covering the same issue differed between countries;
2. co-operation between member countries, the OECD Secretariat, Eurostat and the European Environment Agency in improving the methodologies, data quality and consistency for the nitrogen and phosphorus balances; and,
3. improvements in the methodologies and reporting of international agencies from which data has been drawn for this report, notably Secretariats to various international environmental agreements.

Measurability. The collection of data to calculate the indicators in this report has involved a concerted effort to ensure data consistency between countries. This has been made possible, especially through the circulation of standardised AEI questionnaires and an iterative process between the OECD Secretariat and member countries in resolving inconsistencies in indicator definitions and data, as well as differences in data series for the same indicator but drawn from different sources.

Ease of interpretation. The Expert Meetings and discussions with member countries have sought to improve the clarity of the indicators so that they are as unambiguous as possible in terms of what the data and trends mean. Improvements in interpretation have also been made through the presentation of the indicators in the various graphics in the report including, where relevant, the provision of both percentage and absolute changes over time (*e.g.* pesticides), and comparisons of primary agriculture environmental performance with that of other sectors in the economy (*e.g.* for greenhouse gas emissions).

While most of the indicators in this report reveal national trends (largely on an annual basis), there exists important ***spatial variation*** for many indicators. It is beyond the scope and resources of OECD to identify, analyse and measure the national spatial variation for each indicator, but where this is important it is highlighted in the text, especially in the country sections (Chapter 3), and, in some cases, illustrations are provided of such variation (*e.g.* for nutrient balances, in Chapter 1).

4. Structure of the Report

The *Main Report*, on which the *Highlights* in Section I are based, is structured as follows:

- **Chapter 1:** Summarises OECD trends of environmental conditions related to agriculture during the period since 1990 across 9 themes:
  1. Agricultural production and land use.

2. Nutrients (nitrogen and phosphorus).
3. Pesticides (use and risks).
4. Energy (direct on-farm consumption).
5. Soil (water and wind erosion).
6. Water (use and quality).
7. Air (ammonia, methyl bromide use, greenhouse gas emissions).
8. Biodiversity (genetic, wild species and ecosystem diversity).
9. Farm Management (nutrients, pests, soil, water, biodiversity and organic).

Each of these sections (except Section 1) has a common structure as follows:

- ❖ Summary of key trends.
- ❖ Definitions of the relevant indicators.
- ❖ Indicator concepts (*i.e.* the science behind the indicator) and interpretation.
- ❖ Recent trends across OECD countries, since 1990.

For the indicators in Chapter 1 (see list, Annex II.A1) all the primary data used in their calculation and the cross country time series are included on the OECD website at: *www.oecd.org/tad/env/indicators*.

- **Chapter 2:** Describes those indicators (see list, Annex 2.A1, Chapter 2) for which either methodologies and/or data sets are not yet at a stage that allows for representative comparative OECD country coverage. The chapter considers for each indicator the respective environmental issues and definitions, followed by an assessment of how far the work has developed in each case, including identifying the main knowledge gaps that need to be addressed for the indicators to be useful for policy monitoring and evaluation. An overall assessment of the common themes that emerge from this review is provided in terms of examining the indicators against four criteria: policy relevance, analytical soundness, measurability, and ease of interpretation. The indicator themes considered in the chapter cover:
  - ❖ Soil: Erosion, soil biodiversity and soil organic carbon.
  - ❖ Water: Use and quality.
  - ❖ Biodiversity: Genetic, wild species and ecosystem diversity.
  - ❖ Land: Agricultural landscapes and land ecosystem functions.
  - ❖ Farm management: Environmental management plans, nutrients, pests, soil, water, biodiversity, and farm management capacity.
- **Chapter 3:** Examines trends of environmental conditions related to agriculture for each of the 30 OECD member countries since 1990 (including an overview of the European Union). Each country section is introduced by a figure showing the national agri-environmental and economic profile over the average period 2002-04, followed by the text, structured as follows:
  - ❖ Agricultural sector trends and policy context.
  - ❖ Environmental performance of agriculture.
  - ❖ Overall agri-environmental performance.
  - ❖ Bibliography.

For each country a standardised page is provided consisting of three figures. The first figure is the same for every country and compares respective national performance against the OECD overall average for the period since 1990. The other two figures focus on the national trends for two specific themes important to each respective country. Information is also provided for each country, only on the OECD website, concerning:

- ❖ Details of national agri-environmental indicator programmes.
- ❖ National databases relevant to AEIs.
- ❖ Websites relevant to the national AEIs.

The website also includes a translation of the country section into the respective national language, while all 30 countries are available in English and French.

- **Chapter 4:** Provides a selective review to illustrate how AEIs are currently being used as a tool in policy analysis and evaluation, including discussion on:
  - ❖ Using indicators in OECD member country agri-environmental performance reporting.
  - ❖ Incorporating indicators in international agri-environmental performance reviews.
  - ❖ Harnessing indicators as a tool for analysing the linkages between policies, agriculture and the environment.
  - ❖ Identifying the limitations, knowledge gaps and future requirements for AEIs.

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ANNEX II.A1

*List of indicators in Chapter 1**

Theme	Indicator title	Indicator definition (trends over time for all indicators)
I. Soil	***i.* Soil erosion**	1. Area of agricultural land affected by water erosion in terms of different classes of erosion, *i.e.* tolerable, low, moderate, high and severe.
		2. Area of agricultural land affected by wind erosion in terms of different classes of erosion, *i.e.* tolerable, low, moderate, high and severe.
II. Water	***ii.* Water use**	3. Agricultural water use in total national water utilisation.
		4. Agriculture's use of groundwater in total national groundwater utilisation.
		5. Area of irrigated land in total agricultural land area.
	***iii.* Water quality**	6. Nitrate and phosphate contamination derived from agriculture in surface water and coastal waters.
		7. Monitoring sites in agricultural areas that exceed recommended drinking water limits for nitrates and phosphorus in surface water and groundwater (nitrates only).
		8. Monitoring sites in agricultural areas that exceed recommended drinking water limits for pesticides in surface water and groundwater.
		9. Monitoring sites in agricultural areas where one or more pesticides are present in surface water and groundwater.
III. Air	***iv.* Ammonia emissions, acidification and eutrophication**	10. Share of agricultural ammonia emissions in national total ammonia (NH_3) emissions.
	***v.* Methyl bromide use and ozone depletion**	11. Agricultural methyl bromide use expressed in tonnes of ozone depletion potential.
	***vi.* Greenhouse gas emissions and climate change**	12. Gross total agricultural greenhouse gas emissions (carbon dioxide, methane and nitrous oxide), and their share in total greenhouse gas emissions.
IV. Biodiversity	***vii.* Genetic diversity**	13. Plant varieties registered and certified for marketing for the main crop categories (*i.e.* cereals, oilcrops, pulses and beans, root crops, fruit, vegetables and forage).
		14. Five dominant crop varieties in total marketed production for selected crops (*i.e.* wheat, barley, maize, oats, rapeseed, field peas and soyabeans).
		15. Area of land under transgenic crops in total agricultural land.
		16. Livestock breeds registered and certified for marketing for the main livestock categories (*i.e.* cattle, pigs, poultry, sheep and goats).
		17. Three dominant livestock breeds in total livestock numbers for the main livestock categories (*i.e.* cattle, pigs, poultry, sheep and goats).
		18. Livestock (*i.e.* cattle, pigs, poultry and sheep) in endangered and critical risk status categories and under conservation programmes.
		19. Status of plant and livestock genetic resources under *in situ* and *ex situ* national conservation programmes.

* All of the indicators listed in this annex are those which relate to agri-environmental issues faced by most OECD countries, and are based on the best available science and data available for a representative group of countries, as shown in Chapter 1.

Theme	Indicator title	Indicator definition (trends over time for all indicators)
	***viii.* Wild species diversity**	20. Wild species that use agricultural land as primary habitat.
		21. Populations of a selected group of breeding bird species that are dependent on agricultural land for nesting or breeding.
	***ix.* Ecosystem diversity**	22. Conversion of agricultural land area to (land exits) and from (land entries) other land uses (*i.e.* forest land; built-up land, wetlands, and other rural land).
		23. Area of agricultural semi-natural habitats (*i.e.* fallow land, farm woodlands) in the total agricultural land area.
		24. National important bird habitat areas where intensive agricultural practices are identified as either posing a serious threat or a high impact on the area's ecological function.
V. Farm management	***x.* Nutrient management**	25. Number (area) of farms (agricultural land area) under nutrient management plans.
		26. Farms using soil nutrient testing (agricultural land regularly sampled and analysed for nutrient content).
	***xi.* Pest management**	27. Arable and permanent crop area under integrated pest management.
	***xii.* Soil management**	28. Arable land area under soil conservation practices.
		29. Agricultural land area under vegetative cover all year.
	***xiii.* Water management**	30. Irrigated land area using different irrigation technology systems.
	***xiv.* Biodiversity management**	31. Agricultural land area under biodiversity management plans.
	***xv.* Organic management**	32. Agricultural land area under certified organic farm management (or in the process of conversion to an organic system).
VI. Agricultural inputs	***xvi.* Nutrients**	33. Gross balance between the quantities of nitrogen (N) inputs (*e.g.* fertilisers, manure) into, and outputs (*e.g.* crops, pasture) from farming.
		34. Gross balance between the quantities of phosphorus (P) inputs (*e.g.* fertilisers, manure) into, and outputs (*e.g.* crops, pasture) from farming.
	***xvii*. Pesticides**	35. Pesticide use (or sales) in terms of tonnes of active ingredients.
		36. Risk of damage to terrestrial and aquatic environments, and human health from pesticide toxicity and exposure.
	***xviii.* Energy**	37. Direct on-farm energy consumption in national total energy consumption.

ANNEX II.A2

*Indicators in Chapter 1 assessed according to the OECD indicator criteria**

Section numbers in Chapter 1[1]	Soil erosion (1.5)		Water use (1.6.1)		
	1. Area of water erosion	2. Area of wind erosion	3. Quantity of water use	4. Quantity of groundwater	5. Area of irrigated land
Figure[2]	1	3	1	4	2
Policy relevance					
1. Number of countries[3]	28	16	21	23	25
2. Contribution of agriculture to environmental impact[4]	n.a.	n.a.	45	55	n.a.
Analytically sound					
1. Science of calculation methodology[5]	Sound	Sound	Average	Weak	Sound
2. Certainty of indicator estimate[6]	High	High	Average	Low	High
Measurable					
1. Number of years of data 1990-2004[7]	4	3	14 (to 2003)	1-5	14 (to 2003)
2. Frequency of data collection[8]	Every 5 years	Every 5 years	Annual	Infrequent	Annual
3. Method of primary data collection[9]	Survey/model	Survey/model	Field/model	Field/model	Census
4. Data coverage (*i.e.* agriculture + forestry + fisheries)[10]	Agriculture	Agriculture	Agriculture	Agriculture	Agriculture
5. Institution collecting data[11]	Government	Government	Government	Government	Government
Interpretation					
1. Easy to interpret[12]	High	High	High	High	High
2. Cross-country comparability[13]	Yes	Yes	Yes	No	Yes

* The indicators included in this annex are those listed in Annex II.A1 (only abbreviated definitions are provided here for each indicator, but see Annex II.A1 for full definitions), which are assessed according to the OECD indicator criteria of: policy relevance; analytical soundness; measurability; and ease of interpretation.

Section numbers in Chapter 1[1]		Water quality (1.6.2)							
		6. Nitrate and phosphate water pollution		7. Nitrate concentrations in water		8. Pesticide concentrations in water		9. Presence of pesticides in water	
Figure[2]		1 + 2		3 + 4		6		5	
Policy relevance									
1. Number of countries[3]		Surface	Coastal	Surface	Ground	Surface	Ground	Surface	Ground
	N	17	8	12	22	7	14	5	5
	P	18	7	9	n.a.				
2. Contribution of agriculture to environmental impact[4]	N	25-80	35-80	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	P	20-70	20-50	n.a.	n.a.				
Analytically sound									
1. Science of calculation methodology[5]		Sound		Sound		Average		Average	
2. Certainty of indicator estimate[6]		High		High		Average		Average	
Measurable									
1. Number of years of data 1990-2004[7]	N	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5
	P	1-5	1-5	1-5	1-5				
2. Frequency of data collection[8]		Infrequent		Infrequent		Infrequent		Infrequent	
3. Method of primary data collection[9]		Sample survey		Sample survey		Sample survey		Sample survey	
4. Data coverage (*i.e.* agriculture + forestry + fisheries)[10]		Agriculture		Agriculture		Agriculture		Agriculture	
5. Institution collecting data[11]		Government		Government		Government		Government	
Interpretation									
1. Easy to interpret[12]		High		High		High		High	
2. Cross-country comparability[13]		Yes		Yes		Yes		Yes	

Section numbers in Chapter 1[1]	Ammonia (1.7.1)	Methyl bromide (1.7.2)	GHGs (1.7.3)	Genetic diversity (1.8.1)	
	10. Quantity of ammonia emissions	11. Quantity of methyl bromide use	12. Gross total agricultural GHG emissions	13. Plant varieties marketed	14. Dominant crop varieties
Figure[2]	2	1	1	2	3
Policy relevance					
1. Number of countries[3]	24	30	28	19	9
2. Contribution of agriculture to environmental impact[4]	93	8	8	n.r.	n.r.
Analytically sound					
1. Science of calculation methodology[5]	Sound	Sound	Sound	Weak	Weak
2. Certainty of indicator estimate[6]	High	High	Low	Low	Average
Measurable					
1. Number of years of data 1990-2004[7]	14 (to 2003)	15	15	1-5	1-5 (to 2002)
2. Frequency of data collection[8]	Annual	Annual	Annual	Infrequent	Infrequent
3. Method of primary data collection[9]	Model	Model	Model	Survey	Survey
4. Data coverage (*i.e.* agriculture + forestry + fisheries)[10]	Agriculture	Agriculture + agro-food sector	Agriculture, forestry, fisheries	Agriculture	Agriculture
5. Institution collecting data[11]	UNECE	UNEP	UNFCCC	Government	Government
Interpretation					
1. Easy to interpret[12]	Average	Average	High	Low	Low
2. Cross-country comparability[13]	Yes	Yes	Yes	Yes	Yes

Section numbers in Chapter 1[1]	Genetic diversity *(cont.)*				
	15. Area of transgenic crops	16. Livestock breeds marketed	17. Dominant livestock breeds	18. Number of livestock endangered	19. Status of genetic resources
Figure[2]	Table 1	4	5	6	Tables 2 + 3
Policy relevance					
1. Number of countries[3]	30	16	13	16	17
2. Contribution of agriculture to environmental impact[4]	n.r.	n.r.	n.r.	n.r.	n.r.
Analytically sound					
1. Science of calculation methodology[5]	Sound	Weak	Weak	Sound	Sound
2. Certainty of indicator estimate[6]	High	Low	Low	High	High
Measurable					
1. Number of years of data 1990-2004[7]	16 (to 2005)	1-5 (to 2002)	1-5 (to 2002)	1-5 (to 2002)	1-5 (to 2002)
2. Frequency of data collection[8]	Annual	Infrequent	Infrequent	Infrequent	Infrequent
3. Method of primary data collection[9]	Survey	Survey	Survey	Survey	Survey
4. Data coverage (*i.e.* agriculture + forestry + fisheries)[10]	Agriculture	Agriculture	Agriculture	Agriculture	Agriculture
5. Institution collecting data[11]	ISAAA (NGO)	Government	Government	Government/NGO	Government
Interpretation					
1. Easy to interpret[12]	High	Low	Low	High	Average
2. Cross-country comparability[13]	Yes	Yes	Yes	Yes	Yes

Section numbers in Chapter 1[1]	Wild species diversity (1.8.2)		Ecosystem diversity (1.8.3)		
	20. Wild species using farmland	21. Populations of breeding birds	22. Conversion of agricultural land	23. Area of semi-natural habitats	24. National bird habitat areas
Figure[2]	7	8	9	Table 5	13
Policy relevance					
1. Number of countries[3]	11	17	8	18	22
2. Contribution of agriculture to environmental impact[4]	n.c.	n.c.	n.c.	n.c.	n.c.
Analytically sound					
1. Science of calculation methodology[5]	Average	Sound	Sound	Average	Sound
2. Certainty of indicator estimate[6]	Average	High	High	Average	High
Measurable					
1. Number of years of data 1990-2004[7]	1-5	15	5	14 (to 2003)	1-5
2. Frequency of data collection[8]	1-5	Annual	1-5	Annual	1-5
3. Method of primary data collection[9]	Survey	Survey	Census	Census	Survey
4. Data coverage (*i.e.* agriculture + forestry + fisheries)[10]	Agriculture	Agriculture	Agriculture	Agriculture	n.r.
5. Institution collecting data[11]	Government	BirdLife International (NGO)	Government	Government	BirdLife International (NGO)
Interpretation					
1. Easy to interpret[12]	High	High	High	Average	Average
2. Cross-country comparability[13]	No	Yes	No	Yes	Yes

Section numbers in Chapter 1[1]	Nutrient management (1.9.2)		Pest management (1.9.3)
	25. Nutrient plans	26. Soil nutrient testing	27. Integrated pest management
Figure[2]	1.1 + 1.2	1.3	2.1
Policy relevance			
1. Number of countries[3]	16	12	12
2. Contribution of agriculture to environmental impact[4]	n.a.	n.a.	n.a.
Analytically sound			
1. Science of calculation methodology[5]	Average	Sound	Average
2. Certainty of indicator estimate[6]	Average	High	Average
Measurable			
1. Number of years of data 1990-2004[7]	1-5	1-5 (to 2003)	1-5
2. Frequency of data collection[8]	1-5	1-5	1-5
3. Method of primary data collection[9]	Sample survey	Sample survey	Sample survey
4. Data coverage (*i.e.* agriculture + forestry + fisheries)[10]	Agriculture	Agriculture	Agriculture
5. Institution collecting data[11]	Government	Government	Government
Interpretation			
1. Easy to interpret[12]	Average	Average	Average
2. Cross-country comparability[13]	No	Yes	No

Section numbers in Chapter 1[1]	Soil management (1.9.4)		Water management (1.9.5)	Biodiversity management (1.9.6)	Organic management (1.9.7)
	28. Soil conservation	29. Vegetative cover	30. Irrigation technologies	31. Biodiversity management plans	32. Organic farming
Figure[2]	3.1	3.2	4.1	5.1	6.1
Policy relevance					
1. Number of countries[3]	13	10	14	9	30
2. Contribution of agriculture to environmental impact[4]	n.a.	n.a.	n.a.	n.a.	n.a.
Analytically sound					
1. Science of calculation methodology[5]	Average	Sound	Sound	Weak	Sound
2. Certainty of indicator estimate[6]	Average	High	High	Low	High
Measurable					
1. Number of years of data 1990-2004[7]	1-5 (to 2003)	1-5 (to 2003)	1-5 (to 2003)	1-5 (to 2003)	9
2. Frequency of data collection[8]	1-5	1-5	1-5	1-5	Annual
3. Method of primary data collection[9]	Sample Survey	Sample Survey	Sample Survey	Sample Survey	Survey
4. Data coverage (*i.e.* agriculture + forestry + fisheries)[10]	Agriculture	Agriculture	Agriculture	Agriculture + Forestry	Agriculture
5. Institution collecting data[11]	Government	Government	Government	Government	Government + IFOAM (NGO)
Interpretation					
1. Easy to interpret[12]	Average	High	High	Low	High
2. Cross-country comparability[13]	No	Yes	Yes	No	Yes

Section numbers in Chapter 1[1]	Nutrients (1.2)		Pesticides (1.3)		Energy (1.4)
	33. Nitrogen balance	34. Phos-phorus balance	35. Pesticide use	36. Pesticide risk	37. Farm energy consumption
Figure[2]	2	8	1	3-9	2
Policy relevance					
1. Number of countries[3]	30	30	26	7	30
2. Contribution of agriculture to environmental impact[4]	n.a.	n.a.	n.a.	n.a.	2
Analytically sound					
1. Science of calculation methodology[5]	Sound	Sound	Average	Average	Average
2. Certainty of indicator estimate[6]	High	High	Average	Average	Average
Measurable					
1. Number of years of data 1990-2004[7]	15	15	14 (to 2003)	10	14
2. Frequency of data collection[8]	Annual	Annual	Annual	Annual	Annual
3. Method of primary data collection[9]	Model	Model	Census	Model	Census
4. Data coverage (*i.e.* agriculture + forestry + fisheries)[10]	Agriculture	Agriculture	Agriculture, Forestry	Agriculture	Agriculture, Forestry, Fisheries
5. Institution collecting data[11]	Government	Government	Government	Government	Government
Interpretation					
1. Easy to interpret[12]	Average	Average	High	Low	Average
2. Cross-country comparability[13]	Yes	Yes	Yes	No	Yes

n.a.: Not available. n.r.: Not relevant. n.c.: Not calculated.

1. Section numbers shown in brackets refer to those included in Chapter 1.
2. Figure numbers refer to the figures in each respective section of Chapter 1.
3. "*Number of countries*" – the number of countries for which data are available in the indicators of each respective section of Chapter 1 (*e.g.* 28 of the 30 OECD member countries provided data in the report on agricultural soil water erosion).
4. "*Contribution of agriculture to environmental impact*" – the contribution of OECD agriculture to respective environmental impacts, where relevant, for example, OECD agriculture accounts for 45% of total water use in 2001-03.
5. "*Science of calculation methodology*" – a qualitative assessment – sound, average, weak – of the scientific rigour of each respective indicator's method of calculation.
6. "*Certainty of indicator estimate*" – a qualitative assessment – high, average, low – of the certainty of the estimate made for each indicator.
7. "*Number of years of data 1990-2004*" – the average number of years covered in the figures/tables of each respective section of Chapter 1. Where the time series covers a different period this is indicated.
8. "*Frequency of data collection*" – the frequency (*e.g.* annual to every 5 years) of primary data collection used in the calculation of the indicators.
9. "*Method of primary data collection*" – the method (*e.g.* survey, census) used to collect the primary data to calculate the indicators.
10. "*Data coverage* (i.e. *agriculture + forestry + fisheries)*" – the sectoral (*e.g.* agriculture or agriculture and forestry) coverage of the indicators.
11. "*Institution collecting data*" – the main institution with primary responsibility for collecting data to calculate the indicators.
12. "*Easy to interpret*" – a qualitative assessment – high, average, low – of the ease of interpreting the indicators by policy makers and the wider public.
13. "*Cross-country comparability*" – identification (yes or no) of whether the indicators are comparable across countries.

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Chapter 1

OECD Trends of Environmental Conditions related to Agriculture since 1990

1.1. AGRICULTURAL PRODUCTION AND LAND

KEY TRENDS

OECD countries are major world food suppliers. While projections (2007-16) indicate that the growth in farm production will be lower in OECD countries than for developing countries, the OECD's role as a leading world food exporter is projected to continue.

The projected increase in OECD cereal, meat and milk production is likely to mainly originate in Australia, Canada, Mexico, New Zealand, Turkey and the United States, while production in the EU15 is projected to grow at a rate slower than in the 1990s, and in Japan the farming sector could further contract.

Much of the projected expansion in OECD farm production is likely to originate from raising yields rather than expanding the area cultivated or increasing livestock numbers.

About half of all gains in crop yields over the past 20 years can be attributed to genetic improvement, the remainder is due to improved use of inputs, especially fertilisers, pesticides and irrigation water, and improved management.

OECD agricultural land area accounts for nearly 40% of the total land area, but for around half of OECD member countries farming is the dominant land user, with a share of over 50% in the national land area. Overall the OECD agricultural land area decreased by almost 4% (1990-92 to 2002-04), but increased notably in Belgium, Luxembourg, Mexico, Norway and Turkey.

OECD countries can be classified into four groups in terms of their respective trends in agricultural production, land area, input use (nutrients, pesticides, energy, water) and environmental pressures (1990-2004):

1. *Increasing production and expanding land area:* Mexico and Turkey – potential environmental pressure is increasing due to expanding production and land area, although these countries have a relatively low intensity farming system compared to many other OECD countries.
2. *Increasing production and reduced or near stable land area:* Most countries in this group – Australia, Canada, Korea, New Zealand, Spain, United States – have experienced the highest growth in production on a reduced land area with an overall increase in potential pressure on the environment. In contrast, some EU15 countries and Iceland have experienced slower production growth on less land, but the overall intensity of farming remains a source of high potential environmental pressures.
3. *Decreasing production and land area:* Notably the Czech and Slovak Republics, Hungary, Japan, the Netherlands, Poland and the United Kingdom – leading to an overall lowering of potential pressure on the environment.
4. *Decreasing production, but on an expanding land area:* Norway – with an overall reduction in input use the potential pressure on the environment is declining. However, some of the apparent rise in the area farmed for Norway is due to better reporting.

1.1.1. Introduction

The OECD's ***Driving Force-State-Response (DSR) model***, outlined in Section II, *Background and Scope of the Report*, provides the organising framework for this chapter. The DSR components examined in this chapter include (numbers in brackets indicate the relevant sections in this chapter):

- **Driving forces** – *Farm inputs and outputs*: Agricultural production (1.1.2); Land use (1.1.3); Nutrient use (1.2); Pesticide use (1.3.1); Energy consumption (1.4); Water use (1.6.1).
- **State**
  - *i) Ecosystem:* Pesticide risks (1.3.2); Biodiversity (1.8).
  - *ii) Natural resources:* Soil quality (1.5); Water quality (1.6.2); Air quality (1.7); Biodiversity (1.8).
- **Responses** – *Farmer behaviour:* Farm management practices and systems (1.9).

To set the discussion in the rest of this chapter in a wider context, this section (1.1) examines the: ***driving forces*** of agricultural production and land use as they relate to other key driving forces, especially purchased farm input use (Sections 1.2 to 1.4 and Water use, 1.6.1), which play a major role in affecting the ***state*** of the environment related to agriculture, both on and off-farm (Sections 1.5 to 1.8), and which in turn lead to a ***response*** by farmers in terms of altering their farming practices and systems (Section 1.9).

1.1.2. Agricultural production

OECD countries are major producers of world food supplies. For the main traded agricultural commodities (excluding tropical products) – cereals, meat and dairy products – OECD countries are major global producers (except for rice) and exporters (Tables 1.1.1 and 1.1.2). While OECD agricultural projections from 2007 to 2016 indicate that production growth for crop (except wheat) and livestock products should be appreciably lower in OECD countries than for non-member OECD countries, nevertheless, the OECD's role as a leading world food exporter is projected to continue (OECD, 2007).

OECD agricultural projections for 2007 to 2016, indicate that production may not grow as rapidly as over the period 1990-2005, except for rice (Figure 1.1.1; the assumptions underlying these projections are outlined in OECD, 2006). The projections also suggest that much of the increase in agricultural production is likely to originate from the same countries that showed a rapid growth in production over the 1990s (Figure 1.1.2), mainly **Australia, Canada, Mexico, New Zealand, Turkey** and the **United States**. Overall

Table 1.1.1. **OECD and world agricultural production**

2002-04 (million tonnes)

	OECD	World	% share of OECD in world total
Cereals[1]	**770**	2 132	36
Rice[2]	**31**	587	5
Wheat	**243**	590	41
Milk (cow)	**290**	614	47
Meat[3]	**102**	254	40

StatLink http://dx.doi.org/10.1787/301364511648

1. Cereals: wheat, rice, coarse grains.
2. Only paddy rice production available.
3. Beef and veal, mutton and lamb, pigmeat, poultry and other meats.

Source: FAOSTAT (2006).

Table 1.1.2. **OECD and world agricultural exports**
2002-04 (million tonnes)

	OECD	World	% share of OECD in world total
Cereals[1]	**179**	277	65
Rice[2]	**2**	2	89
Wheat	**83**	116	72
Milk (equivalent)[3]	**69**	78	88
Meat total[4]	**21**	29	72

StatLink http://dx.doi.org/10.1787/301373360557

1. Wheat, rice, coarse grains.
2. Only paddy rice.
3. Milk equivalent of fresh milk, butter, milk powder, cheese and other dairy products.
4. Beef and veal, mutton and lamb, pigmeat, poultry and other meats.

Source: FAOSTAT (2006).

agricultural production in the **EU15** is projected to grow at about the same rate as that experienced over the 1990s, and in **Japan** the farming sector could further contract (Figure 1.1.2). However, production may expand for some **EU15** countries, notably **Spain**, and also for a few new **EU25** entrants, such as **Hungary**.

Much of the expansion in OECD agricultural production is likely to originate from raising yields rather than expanding the cultivated crop area or increasing livestock numbers. For ***crop production*** (*i.e.* coarse grains, wheat and rice), OECD projections reveal that growth in yields are expected to be appreciably higher than the growth in area harvested, and in many cases the area harvested is projected to remain unchanged or decrease while production expands (Figure 1.1.1). About half of all gains in crop yields over the past 20 years can be attributed to genetic improvement, the remainder is due to improved use of inputs, especially fertilisers, pesticides and irrigation water, and enhanced farm management practices (OECD, 2005; Wiebe, 2003).

In the case of ***livestock production***, higher productivity is likely to be achieved through improving feed conversion ratios, especially for pigs and poultry (OECD, 2003); increasing stocking densities per hectare of area grazed for dairy, beef and sheep; and from the greater concentration of livestock in single production units, already well advanced for pigs and poultry, but beginning to take hold in the dairy sector (OECD, 2004b). OECD stocking densities for cattle and sheep showed little change over the period 1990 to 2003, with the exception of an increase in cattle stocking densities in **Canada** and **New Zealand**, and a decline in sheep flocks in **Australia** and **New Zealand**. For most of the key OECD milk producing countries, including the **EU15**, projections (2007-16) indicate an increase in milk production but falling cow numbers, except for **Australia**, **Mexico** and **New Zealand** (Figure 1.1.1).

1.1.3. Agricultural land use

Changes in land use and land cover are among the most important driving forces in global as well as local environmental change. Agriculture is of particular significance in this context as it is for most OECD countries the major user of national land resources (Figure 1.1.3). The environmental implications of changes in agricultural ***land use*** are complex, because they involve changes to other land uses in the economy (*e.g.* to forest and urban use) and in some cases the change of other land uses to farming (*e.g.* from forestry). In addition, there are ***land cover*** changes within agriculture, involving changes in the mix

Figure 1.1.1. **Production, yields and area harvested and future projections for selected commodities and OECD countries**

Annual percentage growth rates

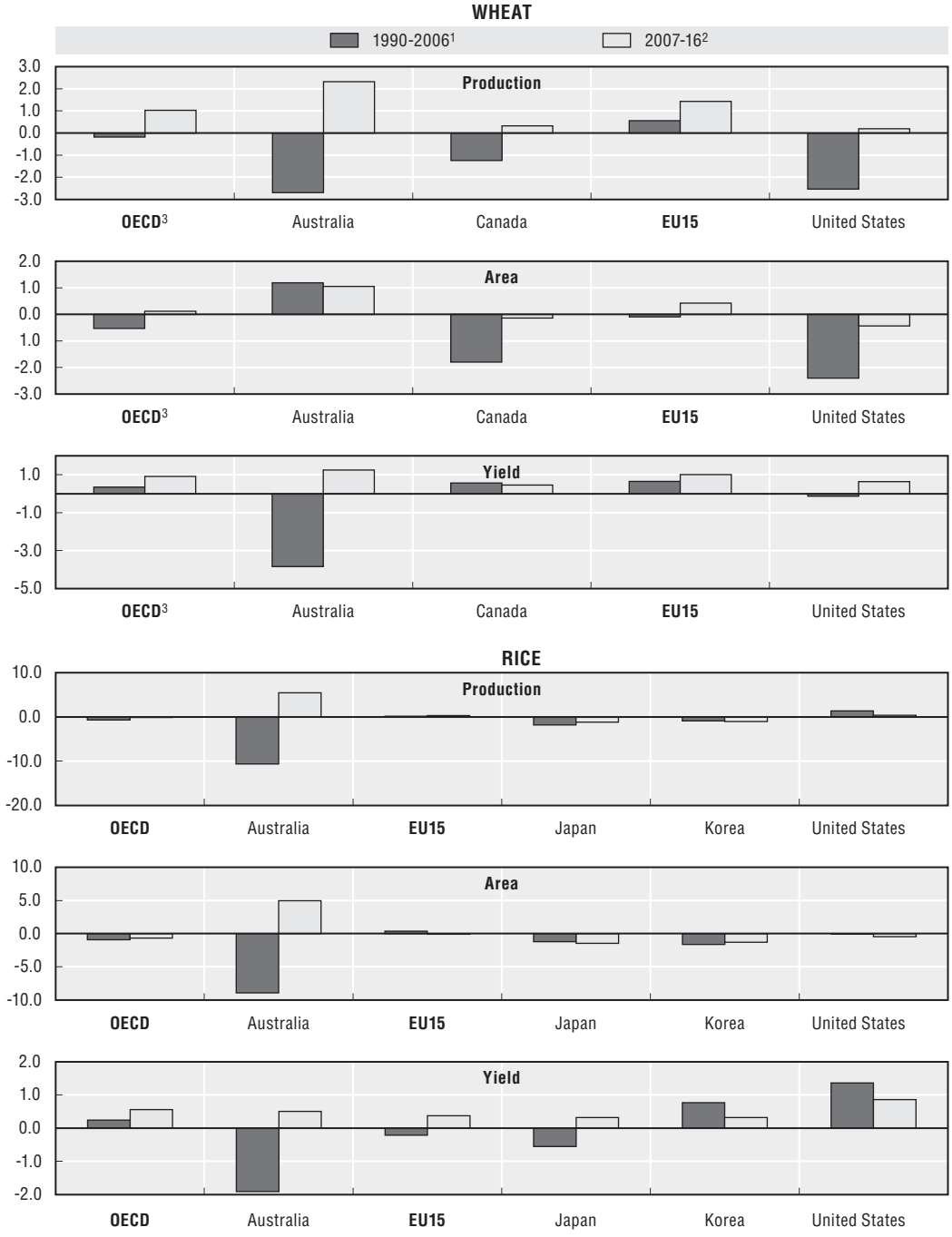
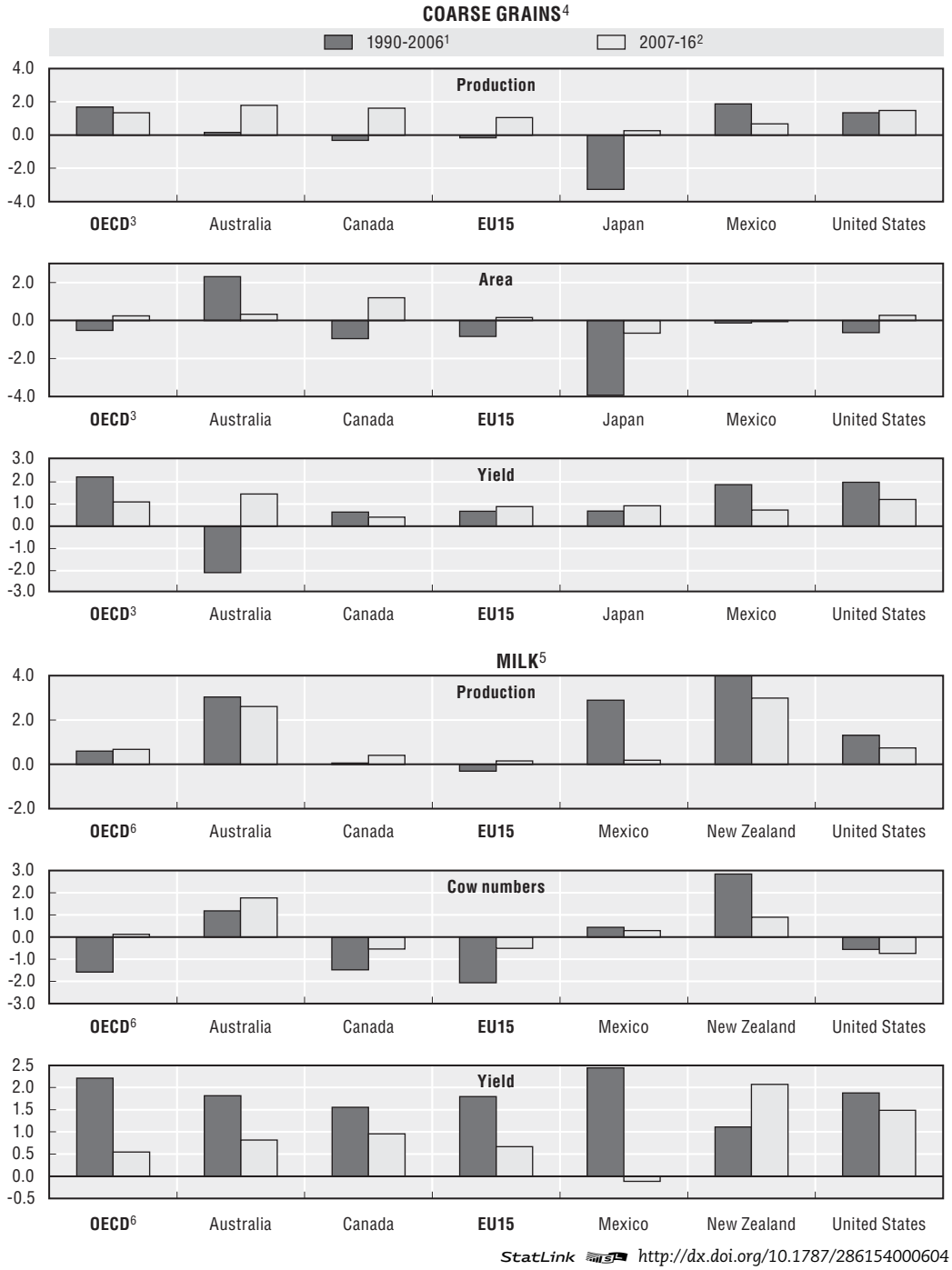


Figure 1.1.1. **Production, yields and area harvested and future projections for selected commodities and OECD countries** *(cont.)*

Annual percentage growth rates



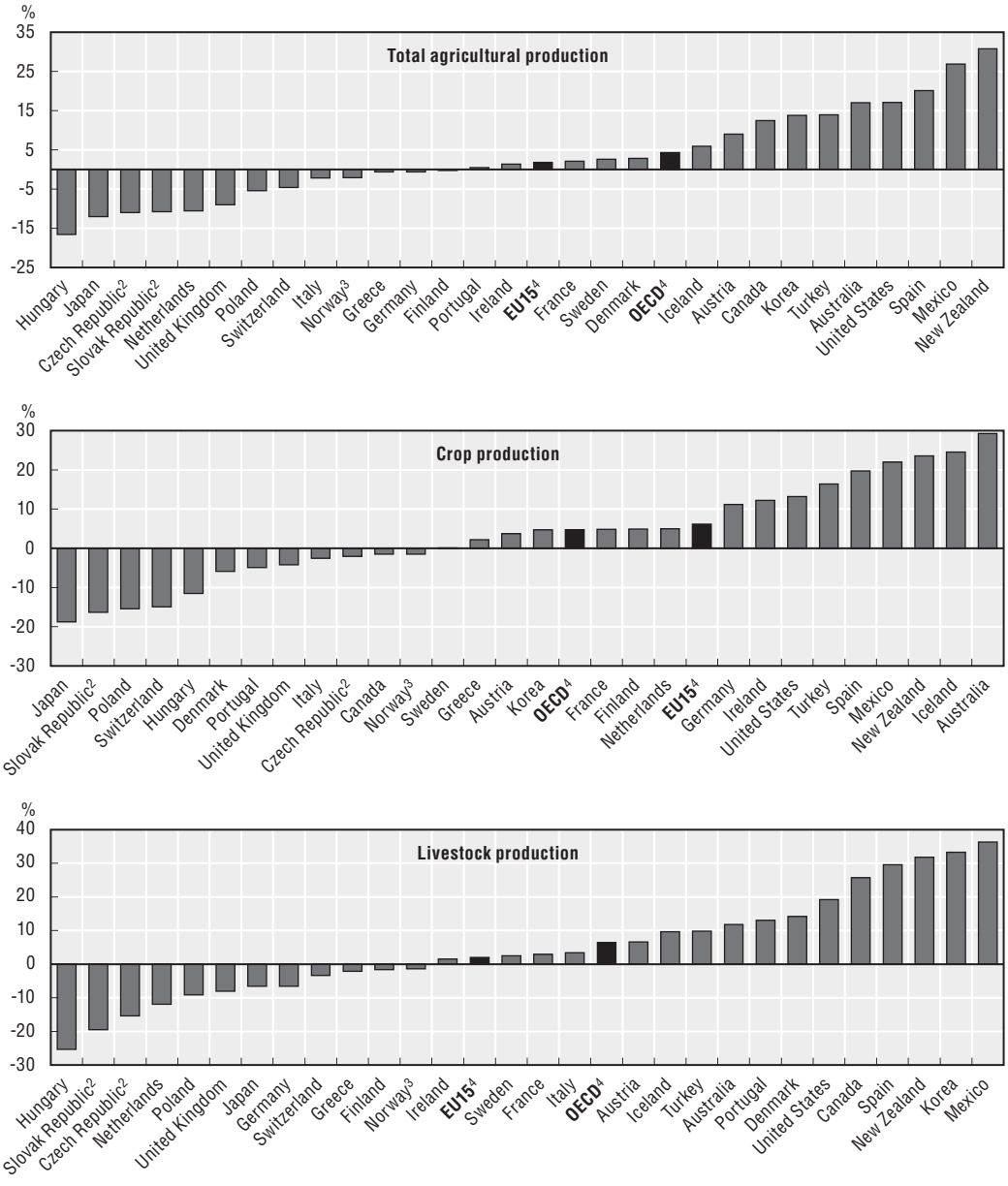
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1. 1990-2006, actual trends, 2006 estimate.
2. 2007-16, projections using the OECD Aglink model, OECD (2007).
3. OECD and country average 1990-2006 = average 1995-2006.
4. Coarse grains include: barley, rye, oats, millets, sorghum, buckwheat, quinoa, fonio, triticale, canary seed, mixed grain and cereals n.e.s.
5. Milk from dairy cows.
6. OECD and country average 1990-2006 = average 1999-2006.

Source: OECD (2007).

Figure 1.1.2. **Volume of total agricultural production**[1]

1990-92 to 2002-04
Base 1999-01 = 100



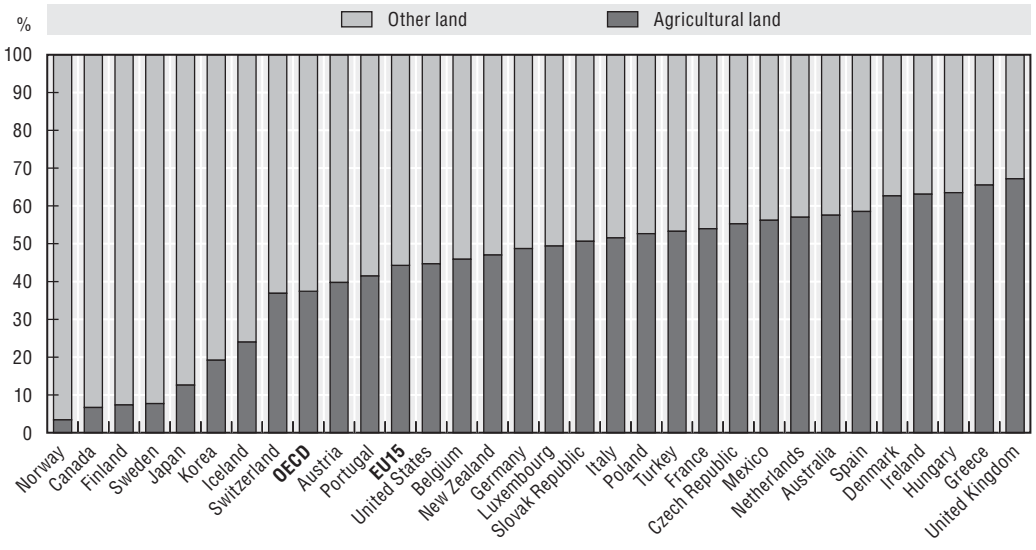
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1. The FAO indices of agricultural production show the relative level of the aggregate volume of agricultural production for each year in comparison with the base period 1999-2001. They are based on the sum of price-weighted quantities of different agricultural commodities produced after deductions of quantities used as seed and feed weighted in a similar manner. The resulting aggregate represents, therefore, disposable production for any use except as seed and feed. All the indices at the country, regional and world levels are calculated by the Laspeyres formula. Production quantities of each commodity are weighted by 1999-2001 average international commodity prices and summed for each year. To obtain the index, the aggregate for a given year is divided by the average aggregate for the base period 1999-2001.
2. Czech Republic and Slovak Republic: average 1990-92 = average 1993-95.
3. National data for Norway.
4. OECD and EU15 excludes Belgium and Luxembourg as data for these countries are only available from 2000 to 2004.

Source: FAOSTAT (2006).

Figure 1.1.3. **Share of agricultural land use in the national land area**

Average 2002-04



StatLink http://dx.doi.org/10.1787/286214753415

Note: National data for Austria, Belgium, Canada, Czech Republic, Denmark, France, Germany, Hungary, Ireland, Japan, Korea, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, and Turkey.

Source: FAOSTAT (2006); and national data.

of arable crops, permanent crops and pasture. But, agricultural land use changes are also complex because of the diversity of land:

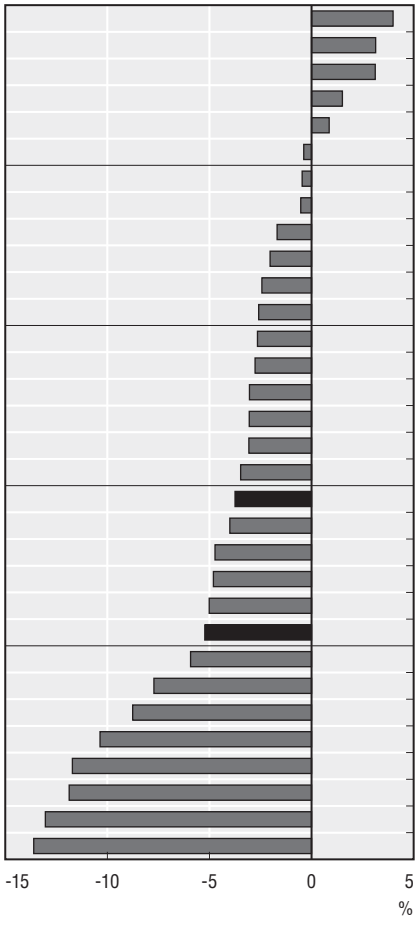
- ***Use***, in commodity production and provision of ecosystem services, such as biodiversity, carbon sequestration, water retention and flood control capacity; and cultural landscape.
- ***Ownership***, in particular, the property right issues related to land and water (OECD, 1997a).
- ***Policies***, that affect land use and management decisions, such as the use of agricultural land diversion programmes in the **EU** and **United States** (OECD, 1997b).

Agricultural land in OECD countries accounts for nearly 40% of the total land area (2002-04), but for around a half of OECD member countries farming is the dominant land user, with a share of over 50% in the national land area (Figure 1.1.3). Overall OECD agricultural land area decreased by almost 4% over the period 1990-92 to 2002-04 (Figure 1.1.4), but for some countries it decreased at over double the OECD average (**Finland, Hungary, Italy, Japan, Korea, Poland** and **United Kingdom**), with much of this land converted to forestry and urban use (Section 1.8).

For a few countries, however, the area farmed has increased, notably **Belgium, Luxembourg, Mexico, Norway** and **Turkey** (Figure 1.1.4). In these countries, except **Mexico** and **Turkey**, some of this increase was due to improved registration and reporting by farmers, in particular, related to stricter requirements with regards to the minimum area for manure spreading and the transition from a farm support system based on production to one based on area.

What are the likely future trends in agricultural land use that are important in terms of environmental effects? Projections for OECD ***crop production*** indicate a potential intensification of cropping, as for many countries the area harvested is expected to decrease while production expands, which could lead to the greater intensity of chemical

Figure 1.1.4. **Agricultural land area**



	Average		Change 1990-92 to 2002-04	
	1990-92	2002-04		
	'000 hectare		'000 hectare	%
Norway	1 002	1 042	40	4.0
Mexico	104 033	107 300	3 267	3.1
Belgium	1 351	1 393	42	3.1
Luxembourg	126	128	2	1.5
Turkey	40 662	41 014	352	0.9
Czech Republic	4 285	4 269	–16	–0.4
Slovak Republic	2 448	2 437	–11	–0.5
Iceland	2 416	2 403	–13	–0.5
Germany	17 288	16 996	–292	–1.7
Greece	8 621	8 446	–175	–2.0
Canada	62 373	60 852	–1 521	–2.4
Ireland	4 465	4 349	–116	–2.6
France	30 492	29 682	–809	–2.7
Austria	3 428	3 333	–95	–2.8
New Zealand	13 006	12 610	–396	–3.0
Switzerland	1 573	1 525	–48	–3.1
Netherlands	1 994	1 932	–61	–3.1
Spain	30 269	29 215	–1 054	–3.5
OECD	**1 301 453**	**1 252 552**	**–48 901**	**–3.8**
United States	426 442	409 367	–17 074	–4.0
Denmark	2 788	2 656	–132	–4.7
Australia	464 367	442 002	–22 364	–4.8
Portugal	3 992	3 792	–200	–5.0
EU15	**146 421**	**138 759**	**–7 662**	**–5.2**
Sweden	3 375	3 175	–200	–5.9
Hungary	6 357	5 865	–491	–7.7
Japan	5 204	4 747	–457	–8.8
United Kingdom	18 143	16 260	–1 883	–10.4
Finland	2 542	2 244	–298	–11.7
Poland	18 686	16 465	–2 221	–11.9
Korea	2 179	1 895	–284	–13.1
Italy	17 546	15 156	–2 390	–13.6

StatLink http://dx.doi.org/10.1787/286243741425

Note: National data for Austria, Belgium, Canada, the Czech Republic, Denmark, France, Germany, Hungary, Ireland, Japan, Korea, Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain and Turkey.

Source: FAOSTAT (2006); and national data.

inputs per hectare cropped (Figure 1.1.1). Projections for grazing livestock suggest that the pressure to stock pasture more intensively or expand the area for grazing is likely to remain stable or even diminish. While beef production is projected to rise over the next decade, this may be offset by lower sheep and dairy cow numbers. Linking possible land use changes to the higher demand for feed from the projected rise in ***pig and poultry*** production is more complex, as it will critically depend on improvements in feed conversion ratios (*i.e.* kilos of feed to produce a kilo of meat/eggs), and how much feed requirements are imported from outside the OECD area.

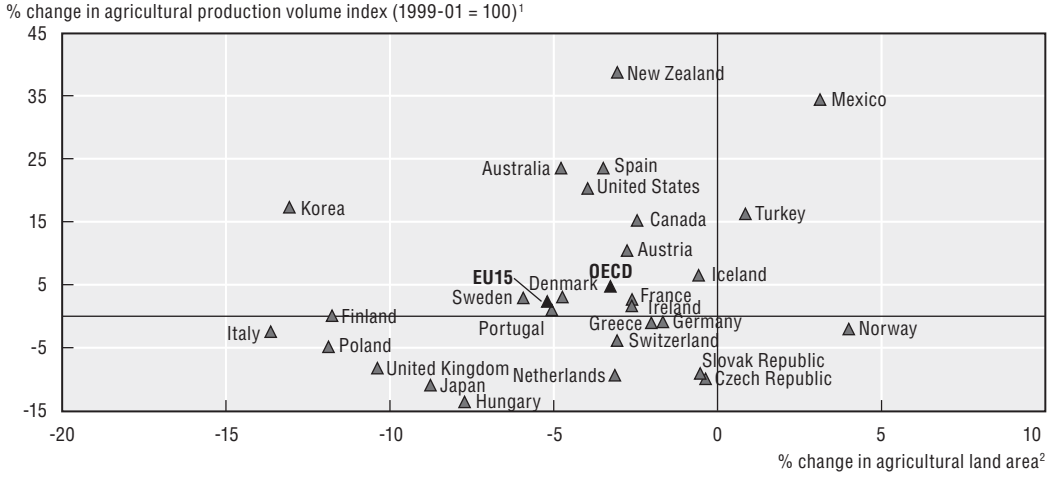
Changes in the overall size and composition of livestock inventories have important implications for discharges of nutrients into soil, water and the air, while changes in stocking densities can have effects on soil erosion and biodiversity. Also the production systems to rear livestock can have varying environmental impacts, such as the increasing trend toward large intensive operations for pigs and poultry and more recently dairy cows.

1.1.4. Linkages between agricultural production and land use

The expansion of agricultural production can be achieved by expanding the land area under production (especially for crops and beef cattle), raising crop and livestock yields through technological improvements, or a combination of both. Based on trends in farm production and land area over the period 1990-92 to 2002-04, OECD countries can be categorised into four broad groups (Figure 1.1.5). Grouping countries in this way helps to identify the implications for the environment. This provides background for the remaining sections of this chapter.

Figure 1.1.5. **Agricultural production volume index and agricultural land area**

1990-92 to 2002-04



StatLink http://dx.doi.org/10.1787/286303650148

1. The agricultural production index is a volume index of total crop and livestock production, see definition Figure 1.1.2. The data included in the figure are averages for 2002-04, with 1999-01 as the base period = 100. Czech Republic and Slovak Republic: Average 1990-92 = average 1993-95. Belgium and Luxembourg are excluded as data are available only from 2000 to 2004.
2. Percentage change in the total national agricultural land area expressed in thousand hectares, 1990-92 to 2002-04.

Source: OECD Secretariat, based on FAOSTAT (2006); and national data.

Group 1: *Increasing production and expanding land area.* For **Mexico** and **Turkey**, the only countries in this group, the potential pressure on the environment from an expanding agricultural sector is increasing. Although Mexico and Turkey are not the most intensive farming systems in the OECD area, there is a risk of an increasing use of environmentally fragile land.

Group 2: *Increasing production, but on a reduced or near stable land area.* Most OECD countries fall under this group, having over the past decade expanded agricultural output by raising productivity and intensifying production on a reduced land area. However, within this group it is possible to discern two broad sub-categories:

- **Australia, Canada, Korea, New Zealand, Spain** and the **United States** have experienced the largest increase in production on a reduced or stable land area. However, with the exception of **Korea**, the overall intensity of production for these countries is lower than for many other OECD countries.

- Some **EU15** member states and **Iceland** have experienced intensification of farm production on a reduced farmed area. However, for most **EU15** countries and **Iceland**, production increases have been considerably lower than for the previous sub-category in the group. Nevertheless, the overall intensity of input use has in most cases been above OECD average levels.

Group 3: *Decreasing production and land area.* The agricultural sectors for this group of countries – notably the **Czech** and **Slovak Republics, Hungary, Japan, the Netherlands, Poland** and the **United Kingdom** – contracted significantly. For **Japan, the Netherlands** and the **United Kingdom**, the overall intensity of input use has been above OECD average levels. However, for the **Czech** and **Slovak Republics, Hungary** and **Poland** agricultural production levels and input use fell sharply (following the transition to a market economy in the early 1990s, but as these countries moved toward EU membership in the late 1990s production levels and input use begun to rise.

Group 4: *Decreasing production, but on an expanding land area.* For **Norway** the only country in this group, while agricultural production has declined over the past decade, the area farmed has increased. However, some of the apparent expansion in area farmed is, in part, due to improvements in the land registration system linked to changes in agri-environmental policies, which also applies to **Belgium** (not shown in Figure 1.1.5 as production data are not available) where the area of agricultural land rose by 3% over the past decade.

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1.2. NUTRIENTS

KEY TRENDS

Overall the quantity of OECD agricultural nutrient balance surpluses declined between 1990-92 and 2002-04, by –4% for nitrogen and –19% for phosphorus, potentially reducing the environmental pressures on soil, water and air. OECD nutrient use efficiency (*i.e.* the ratio of nutrient outputs to nutrient inputs) has also improved, but more markedly for phosphorus than nitrogen. In part this trend reflects the increase in the OECD total use of inorganic nitrogen fertilisers by 3% over the period 1990-92 to 2002-04 compared to a reduction of –10% for phosphate fertilisers, although livestock manure is also an important source of nutrient surpluses for most countries.

While the intensity of nutrient balance surpluses per hectare of agricultural land across the OECD declined by 17%, for nitrogen, the reduction was larger at 37% for phosphorus. Despite the greater reduction in phosphorus compared to nitrogen surpluses from agriculture, the accumulation of phosphorus in agricultural soils is a concern (because of its physical interaction in the environment), particularly the future potential pollution of water bodies.

Nutrient balance surpluses increased mainly in non-European OECD countries, including Australia, Canada, New Zealand, and the United States, although Spain was an exception to this trend, as well as Hungary, Ireland and Portugal where nitrogen surpluses (but not phosphorus) have risen. But in most countries where nutrient surpluses have been rising they mostly had an intensity of nutrient surplus per hectare of farmland well below the OECD average in 2002-04. At the same time for countries where nutrient surpluses have sharply decreased some of them continue to have the highest intensities of nutrient surpluses across the OECD, notably Belgium, Japan, Korea, and the Netherlands.

Where increases in nutrient surpluses into the environment have been the highest over the period 1990-92 to 2002-04 this is largely linked to an overall expansion in agricultural production, especially leading to a greater use of fertilisers and growth in livestock numbers. For Australia and to a lesser extent Hungary, however, it has been the very high rates of growth in fertiliser use that has mainly driven the rising nitrogen surpluses, as overall livestock numbers have declined, although for Canada, New Zealand, Portugal, Spain and the United States, both fertiliser use and livestock numbers have increased.

Overall where ***adoption of nutrient management plans*** and environmental farm plans has been high relative to most other OECD countries, this has had an impact in reducing nutrient surpluses. Even so, for many such countries there is further potential to reduce nutrient surpluses to levels that are not environmentally damaging. Also for some countries where nutrient use efficiency is low by average OECD levels (Japan, Korea), their nutrient surplus intensity per hectare is higher than the OECD average and they have a poor uptake by farmers of nutrient management plans.

The ***principal sources of nutrient inputs*** into OECD farming systems derive from inorganic fertilisers and the nutrient content of livestock manure, which together comprise around 67% of nitrogen inputs and 97% of phosphorus inputs for the OECD on average in 2002-04. In some countries, however, inputs of nitrogen from atmospheric deposition and biological nitrogen fixation can be important. For nutrient outputs, or the uptake of nutrients by harvested crops and pasture, this varies greatly across countries depending on different agro-ecosystems, for example, largely pasture based in Ireland and New Zealand but mainly cereals in Hungary and Japan.

In most countries there is ***considerable variation in the level and trends of regional nutrient balance surpluses*** around national average values. Regional variations are largely explained by the spatial distribution of intensive livestock farming and also cropping systems that require high nutrient inputs, such as maize and rice relative to wheat and oilseeds.

Indicator definitions:

- Gross balance between the quantities of **nitrogen** (N) inputs (*e.g.* fertilisers, manure) into, and outputs (*e.g.* crops, pasture) from farming.
- Gross balance between the quantities of **phosphorus** (P) inputs (*e.g.* fertilisers, manure) into, and outputs (*e.g.* crops, pasture) from farming.

Concepts and interpretation

Inputs of nutrients, such as nitrogen and phosphorus, are important in farming systems as they are critical in raising crop and forage productivity, and a nutrient deficiency can impair soil fertility and crop yields. A build up of surplus nutrients in excess of immediate crop and forage needs, however, can lead to nutrient losses representing not only a possible cause of economic inefficiency in nutrient use by farmers, but especially a source of potential harm to the environment. This can occur in terms of water pollution (*e.g.* eutrophication of surface water caused by nutrient runoff and groundwater pollution by leaching), and air pollution, notably ammonia, as well as greenhouse gas emissions. An additional environmental issue concerns the sustainability of phosphorus resources, as world reserves are diminishing (Johnston and Steén, 1997).

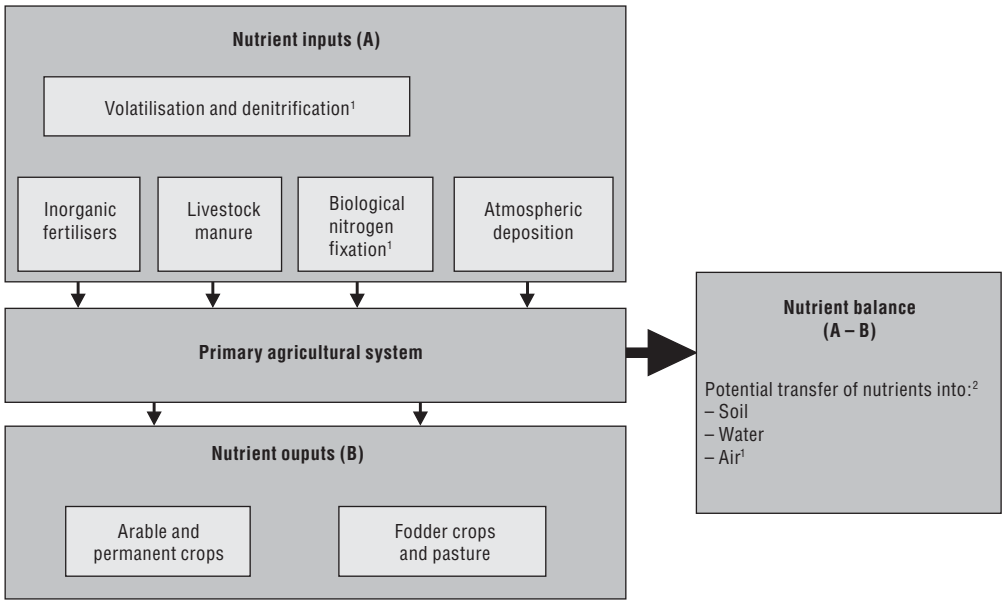
There are a complex range of physical processes that affect nutrient supplies in an agricultural system, illustrated by nutrient cycles (OECD, 2005a; 2005b). The extent to which these processes can harm the environment will depend on the: type of nutrients applied to crops; efficiency of crop nutrient use; type of crop and livestock systems; environmental assimilative capacity of an agro-ecosystem; farming practices; and economic and policy drivers (*e.g.* fertiliser prices and crop subsidies).

The OECD ***gross nutrient balances*** are calculated as the difference between the total quantity of nutrient inputs entering an agricultural system, and the quantity of nutrient outputs leaving the system (Figure 1.2.1). This calculation can be used as a proxy to reveal the status of environmental pressures, such as declining soil fertility in the case of a nutrient deficit, or for a nutrient surplus the risk of polluting soil, water and air. The methodology has been jointly developed by OECD country nutrient experts and the OECD and Eurostat Secretariats (OECD, 2007a; 2007b).

The nutrient balance indicator is expressed here in terms of the kilograms of nutrient surplus (deficit) per hectare of agricultural land per annum. This expression of nutrient balances facilitates the comparison of the relative intensity of nutrients in agricultural systems between countries (*e.g.* very high in **Korea** and very low in **Australia**, Figures 1.2.2 and 1.2.8), and also helps describe the main sources of nutrient inputs and outputs. In addition, the nutrient balances are expressed in terms of changes in the physical quantities of nutrient surpluses (deficits), which provide an indication of the trend and level of potential physical pressure of nutrient surpluses into the environment (*e.g.* rising in **Canada** and declining in **Finland**, Figures 1.2.2 and 1.2.8).

It should be stressed that the methodology is a gross balance calculation which takes account of all the total potential, not effective, losses of nutrients into the environment (*i.e.* soil, water and air). This includes for the ***nitrogen balance*** ammonia (NH_3) volatilisation during the process of manure accumulation and manure storage and nitrogen losses from the soil (leaching, denitrification, and ammonia volatilisation). Denitrification, which is the

Figure 1.2.1. **Main elements in the OECD gross nutrient (nitrogen and phosphorus) balance calculation**



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1. Applies to the nitrogen balance only.
2. Nutrients surplus to crop/pasture requirements are transported into the environment, potentially polluting soils, water and air, but a deficit of nutrients in soils can also occur to the detriment of soil fertility and crop productivity.

Source: OECD (2007a; 2007b).

conversion of soil nitrate to nitrogen gases, mainly occurs under anaerobic conditions (*e.g.* wet paddy rice and wet soil conditions). This process leads to the release of both dinitrogen gas (N_2) which is not harmful to the environment or human health, and also nitrous oxide (N_2O) which although released in small amounts is a very potent greenhouse gas (see Section 1.7.3). The components of the ***phosphorus balance*** are similar to the nitrogen balance, but exclude emission factors for volatilisation and biological nitrogen fixation.

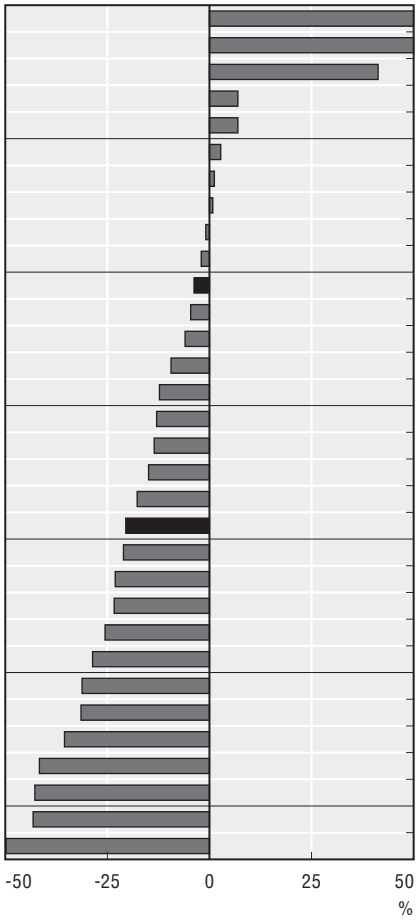
While the nutrient balances are calculated at the national level, the same methodology can be used to estimate regional (sub-national) balances. This is important given the significant spatial variation in balances around national average values. Hence, national values need to be interpreted with caution. At present, however, nutrient balances in this section are only provided at the national level, although some examples of regional balances are discussed for illustrative purposes at the end of the section (Figure 1.2.12).

Caution is required in linking trends in nutrient balances and environmental impacts, as the balances only reveal the *potential* for environmental pollution and are not necessarily indicative of actual resource depletion or environmental damage. The information provided by nutrient balances, however, is useful for analytical purposes, such as modelling the environmental effects of agricultural and agri-environmental policies. This is because of its input-output and whole farm system approach to nutrients, rather than the more limited value of a fertiliser use per hectare indicator which only provides a restricted view of nutrients in farming systems, especially as it excludes livestock manure.

Limitations of nutrient balances include the accuracy of the underlying nutrient conversion coefficients and also the uncertainties involved in estimating nutrient uptake by areas of pasture and some fodder crops. In addition, environmental events like droughts and

Figure 1.2.2. **Gross nitrogen balance estimates**

Change in the nitrogen balance (tonnes N)[1]



	Balance expressed as tonnes of nitrogen (N)				Balance expressed as kg nitrogen per hectare of total agricultural land		
	Average		Change		Average		Change
	1990-92	2002-04	1990-92 to 2002-04		1990-92	2002-04	1990-92 to 2002-04
	000' tonnes N		000' tonnes N	%	Kg N/ha		%
Canada[2]	1 168	2 101	934	80	19	35	85
Hungary[2]	136	217	82	60	21	37	74
New Zealand	407	576	169	41	31	46	46
Ireland	337	360	24	7	76	83	9
Portugal	168	180	12	7	42	47	13
United States	14 621	15 024	402	3	34	37	7
Spain	966	977	12	1	32	33	5
Australia[3]	7 574	7 636	62	1	16	17	5
Italy	588	582	–5	–1	33	39	16
Korea	465	456	–9	–2	213	240	13
OECD	**41 238**	**39 681**	**–1 557**	**–4**	**88**	**74**	**–17**
Switzerland	121	116	–6	–5	77	76	–1
Iceland	17	16	–1	–6	7	7	–5
Czech Republic	332	300	–31	–9	77	70	–9
Norway	92	81	–11	–12	92	77	–16
Japan	935	813	–121	–13	180	171	–5
Poland	922	797	–125	–14	49	48	–2
Mexico	2 768	2 354	–414	–15	27	22	–18
France	1932	1 589	–343	–18	63	54	–16
EU15	**9 989**	**7 935**	**–2 054**	**–21**	**113**	**83**	**–26**
Sweden	193	152	–41	–21	57	48	–16
Turkey	1 493	1 148	–346	–23	37	28	–24
Germany	2 515	1926	–589	–23	145	113	–22
Belgium	344	256	–88	–26	255	184	–28
Austria	226	161	–65	–29	66	48	–27
United Kingdom	1 022	702	–320	–31	56	43	–23
Denmark	493	338	–156	–32	178	127	–29
Netherlands	688	443	–245	–36	345	229	–34
Finland	211	123	–88	–42	83	55	–34
Luxembourg	29	16	–12	–43	229	129	–44
Slovak Republic	197	111	–85	–43	80	46	–43
Greece	278	130	–149	–53	32	15	–52

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1. The gross nitrogen balance calculates the difference between the nitrogen inputs entering a farming system (*i.e.* mainly livestock manure and fertilisers) and the nitrogen outputs leaving the system (*i.e.* the uptake of nutrients for crop and pasture production).
2. For Canada, change in the nitrogen balance is +80%. For Hungary, change in the nitrogen balance is +60%. For Greece, change in the nitrogen balance is –53%.
3. Average for the period 2002-04 is an OECD estimate.

Source: OECD Secretariat (2007).

floods will affect the efficiency of plants to fix nutrients, the soil science of nutrients is not well understood (*e.g.* soils vary in their capacity to store nutrients), while there is limited information on the varietal mix of legumes in pastures to accurately estimate pasture uptake of nitrogen. While other approaches that estimate agricultural nutrient surpluses can overcome some of these problems, such as the farm gate balance method (van Eerdt and Fong, 1998) and the **New Zealand** Overseer model (Ledgard *et al.*, 2005), the data required to calculate such models are not widely available across most OECD countries.

As an environmental ***driving force***, nutrient balance indicators link to the ***state*** (or concentration) of nutrients in water bodies (Section 1.6.2) and ammonia, and greenhouse gas emissions (Section 1.7). ***Responses*** to these changes in the state of the environment are revealed through indicators of nutrient management and environmental farm planning, including organic farming (Section 1.9).

Recent trends

Overall OECD agricultural nutrient balance surpluses (tonnes) declined between 1990-92 and 2002-04, by 4% for nitrogen and 19% for phosphorus, potentially reducing the environmental pressures on soil, water and air (Figures 1.2.2, 1.2.8). OECD nutrient use efficiency (*i.e.* the ratio of nutrient outputs to nutrient inputs) has also improved, but more markedly for phosphorus than nitrogen (Figures 1.2.7, 1.2.11). In part this trend reflects the increase in the OECD total use of nitrogenous fertilisers by 3% over the past 15 years compared to a reduction of 10% for phosphate fertilisers (Figure 1.2.5), although livestock manure is also an important source of nutrient surpluses for most countries. Moreover, while the intensity of nitrogen surpluses per hectare of agricultural land across the OECD declined by 17%, for phosphorus the reduction was larger at 37% (Figures 1.2.2, 1.2.8). Despite the greater reduction in phosphorus compared to nitrogen surpluses from OECD agriculture, the accumulation of phosphorus in agricultural soils is a concern (because of its physical interaction in the environment), particularly for the future potential pollution of water bodies.

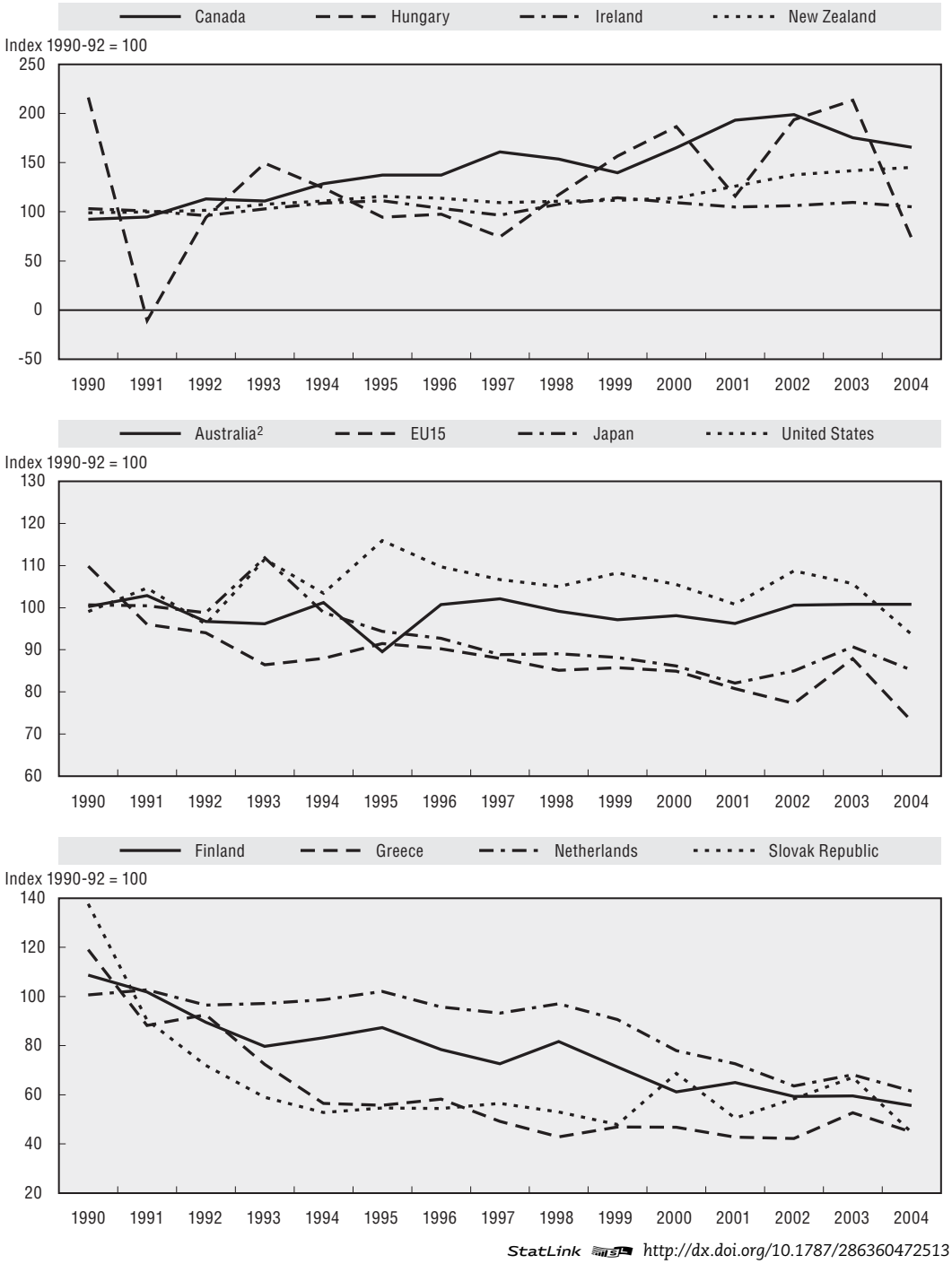
1.2.1. Nitrogen balance

Total tonnes of OECD nitrogen (N) balance surplus declined by 4% over the period 1990-92 to 2002-04 (Figure 1.2.2). N surpluses showed the largest increases mainly in non-European countries (**Canada, New Zealand**), but also rose in **Australia** and the **United States**, and in Europe for **Hungary, Ireland, Portugal** and **Spain**. But despite the increases in nitrogen surpluses in these countries, with the exception of **Ireland**, they had an intensity of kgN/ha of agricultural land well below the OECD average in 2002-04 (Figure 1.2.2). At the same time for many countries where tonnes of N surpluses have shown large reductions over the past 15 years some of them continue to have the highest intensity of kgN/ha of agricultural land across the OECD area, notably **Belgium, Denmark, Germany, Luxembourg** and the **Netherlands** (Figure 1.2.2).

Where increases in N surpluses into the environment have been the highest over the period 1990-92 to 2002-04 this is largely linked to an overall expansion in agricultural production, especially leading to a greater use of fertilisers and growth in livestock numbers (Figures 1.2.3, 1.2.4). For **Australia** and to a lesser extent **Hungary**, however, it has been the very high rates of growth in nitrogen fertiliser use (Figures 1.2.4, 1.2.5) that has mainly driven the rising nitrogen surpluses, as overall livestock numbers have fallen in these countries over the past 15 years, although for **Canada**, **New Zealand**, **Portugal**, **Spain** and the **United States**, both nitrogen fertiliser use and livestock numbers have increased.

Problems of N surplus disposal are also associated with rising animal stocking densities and structural changes in the livestock industry toward large confined operations, especially for pigs, poultry and to a lesser extent dairy cattle (OECD, 2003; 2004). In the **United States**, for example, with the growing number and size of confined livestock operations, over 60% of manure is produced on farms that have insufficient land on their properties to fully absorb the waste (Chapter 3). In addition rising fertiliser demand and growth in N surpluses is, in part, explained in some countries by the expansion in crop production

Figure 1.2.3. **Gross nitrogen balances[1] for selected OECD countries**



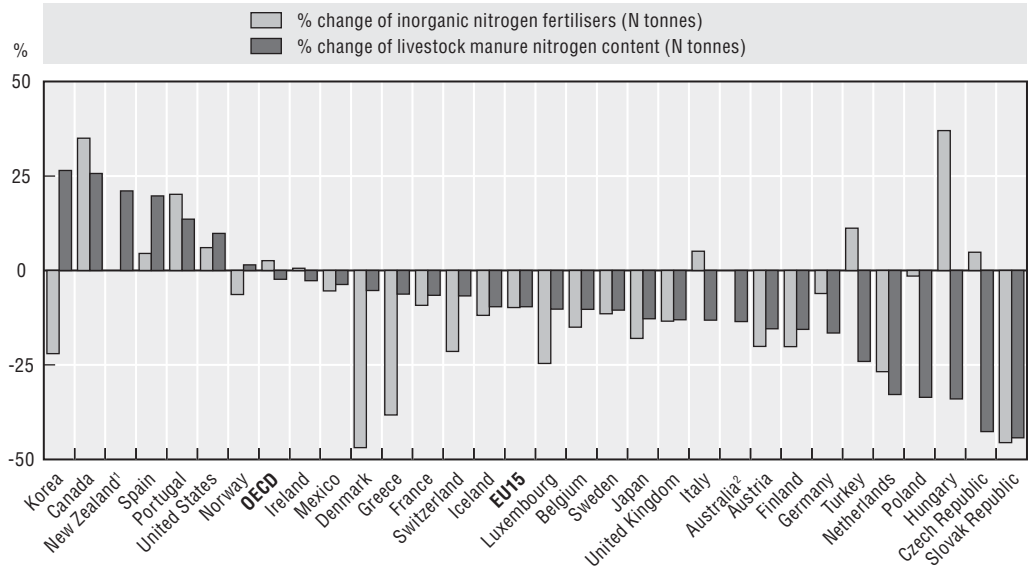
StatLink http://dx.doi.org/10.1787/286360472513

1. The gross nitrogen balance calculates the difference between the nitrogen inputs entering a farming system (*i.e.* mainly livestock manure and fertilisers) and the nitrogen outputs leaving the system (*i.e.* the uptake of nutrients for crop and pasture production).
2. The period 2002-04 is an OECD estimate.

Source: OECD Secretariat (2007).

Figure 1.2.4. **Inorganic nitrogen fertilisers and livestock manure nitrogen input in nitrogen balances**

1990-92 to 2002-04



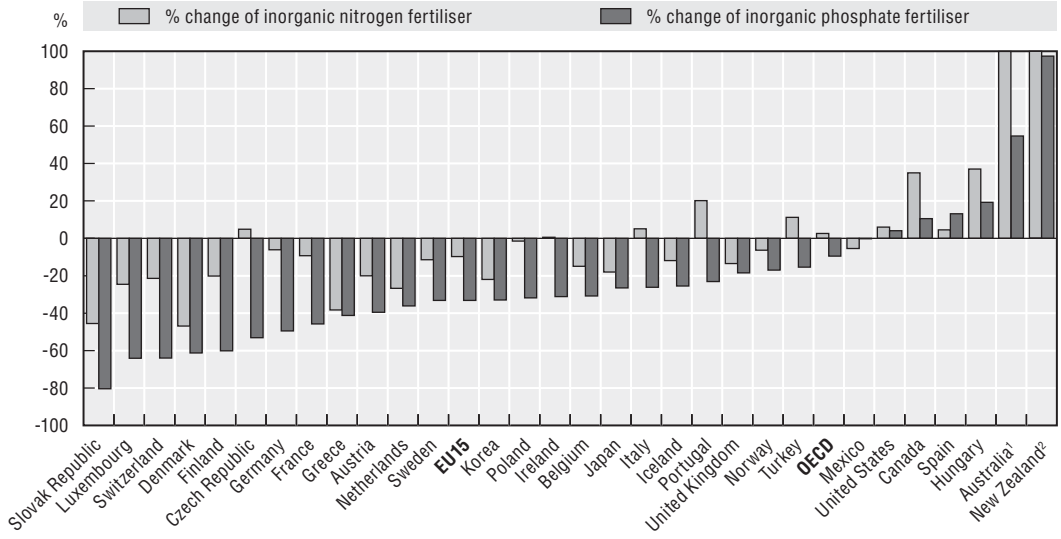
StatLink http://dx.doi.org/10.1787/286364526277

1. For New Zealand, the change in inorganic nitrogen fertilisers is +421%.
2. For Australia, the change in inorganic nitrogen fertilisers is +113%.

Source: OECD Secretariat (2007).

Figure 1.2.5. **Agricultural use of inorganic nitrogen and phosphate fertilisers**

In tonnes product weight % change 1990-92 to 2000-04



StatLink http://dx.doi.org/10.1787/286372021120

1. For Australia, the change in nitrogen fertiliser is 113%.
2. For New Zealand, the change in nitrogen fertiliser is 421%.

Source: OECD Secretariat (2007).

together with a shift in cropping patterns to crops requiring higher fertiliser inputs per kg of output (*e.g.* from wheat to maize, see OECD, 2005, Figure 1.2.2, Section 1.1), such as in **Australia, Canada** and the **United States**. But changes in nitrogen fertiliser use are also because of different agricultural systems between countries (*e.g.* the reduction in rice production in Korea and Japan, but higher use of fertiliser to increase pasture yield in **New Zealand**), restrictions on using fertilisers (**Denmark, Netherlands, Norway**), and relatively greater improvements in N fertiliser use efficiency compared to reducing N emissions from livestock in some cases.

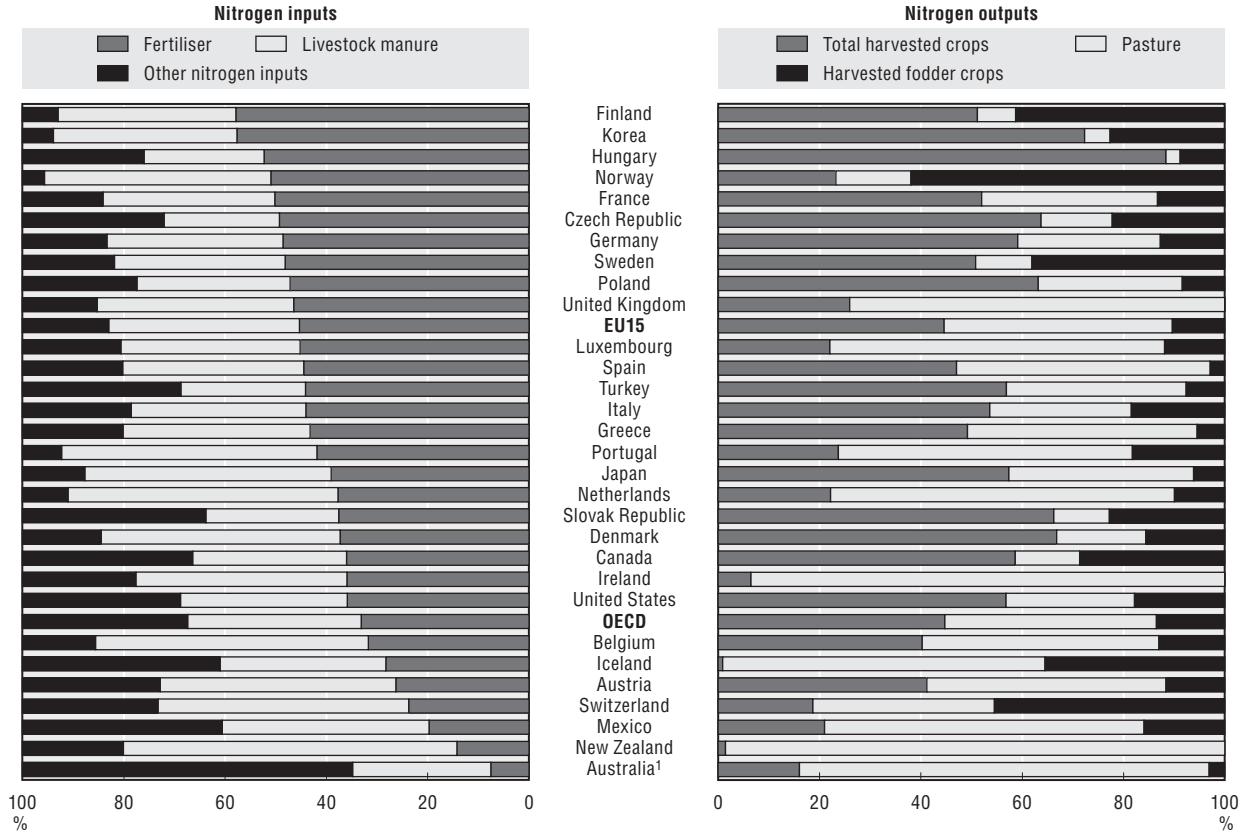
For some countries where N surpluses have risen over the past decade, the uptake of nutrient management plans (NMPs) has been relatively low (**Ireland, New Zealand, Spain**), but for **Canada, Korea** and the **United States** while the uptake of NMPs has been also been relatively low, adoption rates have risen over the 1990s (Section 1.9). Overall where adoption of nutrient management plans and environmental farm plans has been high relative to the OECD average, this has had an impact in reducing N surpluses. Even so, for many such countries there is further potential to reduce agricultural N surpluses to levels that are not potentially environmentally damaging (**Belgium, Denmark, Finland, Germany, Netherlands, Norway, Switzerland**). Moreover, in those countries (**Czech** and **Slovak Republics, Hungary, Poland**) which experienced a sharp reduction in N surpluses following the collapse in farm support levels after the transition to a market economy in the early 1990s, their N surpluses are beginning to rise as they integrate into the **EU25**, markedly so for **Hungary** (Figures 1.2.2, 1.2.3).

The principal sources of N inputs into OECD farming systems derive from nitrogen fertilisers and the nitrogen content of livestock manure, which together comprise around two-thirds of N inputs for the OECD on average (Figure 1.2.6). In some countries, however, other inputs of N, especially from atmospheric deposition (**Australia, Belgium, United Kingdom**) and biological nitrogen fixation can be important (**Ireland, Japan, New Zealand**) (Figure 1.2.6). For certain countries increasing quantities of sewage sludge are being recycled on agricultural land as a fertiliser. Use of sewage sludge in the **EU15** rose by 7% (1995-2000), with larger increases reported for **Ireland, Italy** and **Spain** (EEA, 2005). While the use of sewage sludge as a source of farm nutrients can bring agronomic benefits, its use raises a number of environmental and health concerns (*e.g.* risks of pollution from heavy metals and pathogens) which require careful monitoring (EEA, 2005; Chapter 3). This was the reason why **Switzerland** has decided to forbid the sewage sludge recycling on farmland from 2006 (Chapter 3). ***N output***, or the uptake of N by crops and pasture, varies greatly across countries depending on different agro-ecosystems, for example, largely pasture based in **New Zealand** but mainly harvested crops in **Hungary** (cereals) and **Japan** (rice) (Figure 1.2.6).

Trends in overall N use efficiency (*i.e.* the ratio of N output to N input in an agricultural system, Figure 1.2.7) indicate that a considerable number of countries have improved N use efficiency over the period 1990-92 to 2002-04 (notably for **Belgium, Finland, Greece, Germany, Luxembourg** and **Turkey**). This is partly linked to improvements in reducing inorganic fertiliser input use per unit volume of crop output. In a number of countries, nutrient surpluses from livestock have fallen through altering feeding patterns, storing manure in closed storage systems rather than spreading waste on fields, and also by changing the timing and technologies used to spread manure on fields (OECD, 2003; 2004). But performance is variable across OECD countries. For example, in **Australia** the management of captured manure systems on dairy farms is poor (Chapter 3), while in **Switzerland** most livestock manure is usually stored in some form or other (OECD, 2004).

Figure 1.2.6. **Contribution of the main sources of nitrogen inputs and outputs in nitrogen balances**

Average 2002-04



StatLink http://dx.doi.org/10.1787/286380707372

1. The average for the period 2002-04 is an OECD estimate.

Source: OECD Secretariat (2007).

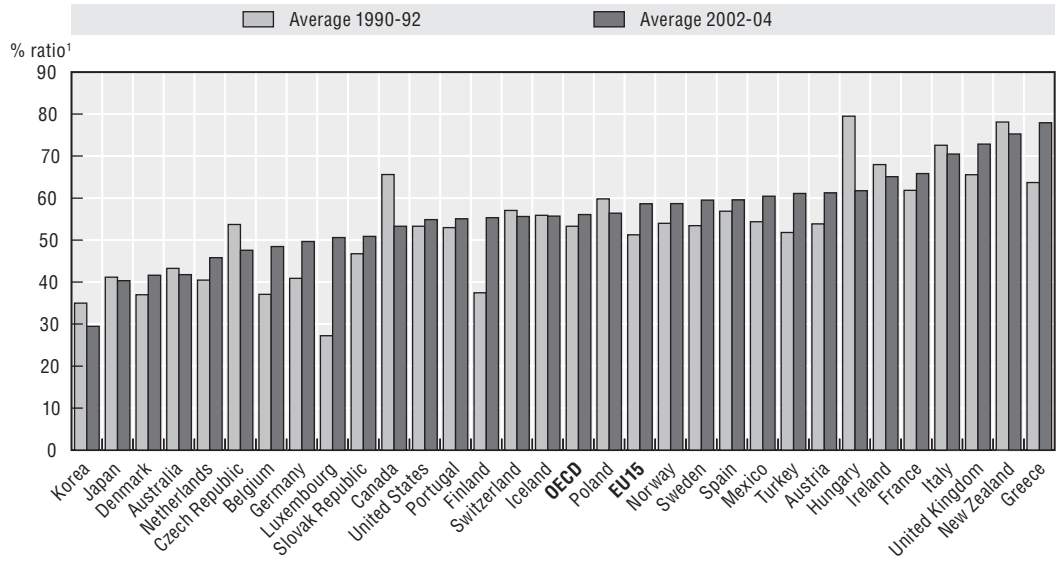
Also for some countries where N use efficiency is low by average OECD levels (**Japan, Korea**) they are also countries with higher than the OECD average intensity of kgN/ha of farmland and poor uptake by farmers of nutrient management plans (Section 1.9).

For a few countries N use efficiency has declined over the past 10 years (mainly **Canada, Hungary** and **Korea**), largely due a combination of a substantial rise in fertiliser use and livestock manure relative to reduced N uptake from crops and forage (Figure 1.2.7). In **Canada**, for example, the decline in N use efficiency over the period 1996 to 2001 was attributed to an increase in pulse crop acreage (*i.e.* greater biological nitrogen fixation) without a concurrent decrease in fertiliser application, lower crop yields, and growing livestock densities in some areas (Lefebvre *et al.*, 2005).

1.2.2. Phosphorus balance

There was a –19% reduction in the OECD total agricultural phosphorus (P) balance surplus (tonnes) over 1992-92 to 2002-04 (Figures 1.2.8, 1.2.9). This was a much larger percentage reduction than for OECD nitrogen surpluses, mainly because of the substantial decrease in phosphate fertiliser use by 10% (Figure 1.2.5). For a considerable number of countries P surpluses (tonnes) declined by more than 50% over the past 15 years (Figure 1.2.8).

Figure 1.2.7. **Nitrogen efficiency[1] based on gross nitrogen balances**



StatLink http://dx.doi.org/10.1787/286407852618

1. Nitrogen efficiency measured as the percentage ratio of total nitrogen uptake by crops and forage (tonnes) to the total nitrogen available from fertiliser, livestock manure, and other nitrogen inputs (tonnes).

Source: OECD Secretariat (2007).

However, the intensity of kgP/ha of agricultural land for some of these countries still remain among the highest across the OECD, notably for the **Netherlands** (Figure 1.2.8). This is in contrast to many of the countries where tonnes of P surpluses have risen although their intensity of kgP/ha of agricultural land was well below the OECD average in 2002-04, notably **Australia, Canada** and the **United States**. For **New Zealand** where the tonnes of the P surplus (tonnes) rose by nearly 130 %, the P intensity level is higher than the OECD average partly reflecting the over 420% rise in phosphate fertiliser use (Figure 1.2.5).

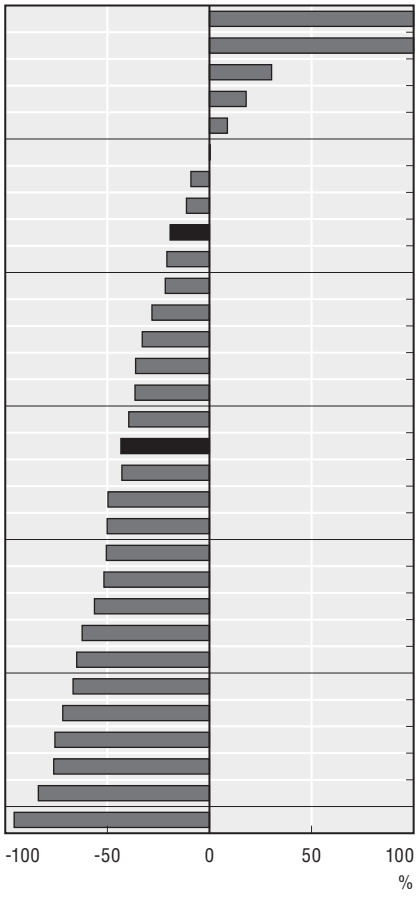
Nearly all the ***P inputs*** into OECD farming systems derive from phosphate fertilisers and the phosphorus content of livestock manure, comprising together well over 90% of P inputs for almost all OECD countries (Figure 1.2.10). As with nitrogen, ***P output***, or the uptake of P by crops and pasture, varies greatly across countries depending on different agro-ecosystems (Figure 1.2.10).

The decline in OECD phosphate (P_2O_5) fertiliser use by 10% over the period 1990-92 to 2002-04 (Figure 1.2.5), largely explains the marked improvement in ***P use efficiency*** (*i.e.* the ratio of P output to P input) over the past 15 years compared to N use efficiency changes (Figures 1.2.7 and 1.2.11). In addition, the improvement in P use efficiency and reduction in P surpluses (tonnes) for most OECD countries is partly because P is more stable in the soil than N and hence, more likely to remain in the soil over longer periods. Thus, repeated phosphorus application to agricultural soils (both from fertilisers and spreading manure) over past decades has led to the gradual accumulation of P in farmed soils for many OECD countries as readily available reserves for crops to harness or to leach into water bodies.

As farmers have become aware of the build-up of P in their soils through more widespread use of soil nutrient tests (Section 1.9), this has led them to reduce P_2O_5 application rates, although this has been reinforced in some cases with government

Figure 1.2.8. **Gross phosphorus balance estimates**

Change in the phosphorus balance (tonnes P)[1]



	Balance expressed as tonnes of phosphorus (P)				Balance expressed as kg phosphorus per hectare of total agricultural land		
	Average		Change		Average		Change
	1990-92	2002-04	1990-92 to 2002-04		1990-92	2002-04	1990-92 to 2002-04
	000' tonnes P		000' tonnes P	%	Kg P/ha		%
New Zealand[2]	76	174	98	128	6	14	136
Canada[3]	37	82	45	123	1	1	137
Australia	309	403	94	30	1	1	35
Spain	194	229	36	18	6	8	23
United States	1 300	1 415	115	9	3	3	13
Portugal	59	59	0	0	15	15	5
Norway	15	14	–1	–9	15	13	–13
Korea	103	92	–12	–11	47	48	2
OECD[4]	**4 743**	**3 829**	**–914**	**–19**	**16**	**10**	**–37**
Iceland	4	3	–1	–21	2	1	–21
United Kingdom	274	215	–59	–22	15	13	–13
Japan	339	243	–95	–28	65	51	–21
Italy	242	162	–80	–33	14	11	–22
Denmark	47	30	–17	–36	17	11	–33
Ireland	44	28	–16	–37	10	6	–35
Turkey	354	214	–140	–39	9	5	–40
EU15	**1 844**	**1 043**	**–800**	**–43**	**18**	**10**	**–48**
Belgium	55	31	–24	–43	41	23	–45
Greece	69	35	–34	–50	8	4	–49
Poland	89	45	–45	–50	5	3	–43
Netherlands	75	37	–38	–51	38	19	–49
Mexico	176	85	–91	–52	2	1	–53
Switzerland	19	8	–11	–56	12	5	–55
Austria	26	10	–16	–62	7	3	–61
Finland	51	18	–33	–65	20	8	–60
Sweden	18	6	–12	–67	5	2	–65
France	404	114	–290	–72	13	4	–71
Germany	281	68	–212	–76	16	4	–75
Luxembourg	6	1	–5	–76	48	11	–77
Czech Republic	43	7	–36	–84	10	2	–84
Slovak Republic	36	2	–35	–96	15	1	–96
Hungary[5]	–9	–1	n.a.	n.a.	–4	–1	n.a.

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n.a.: Not available.

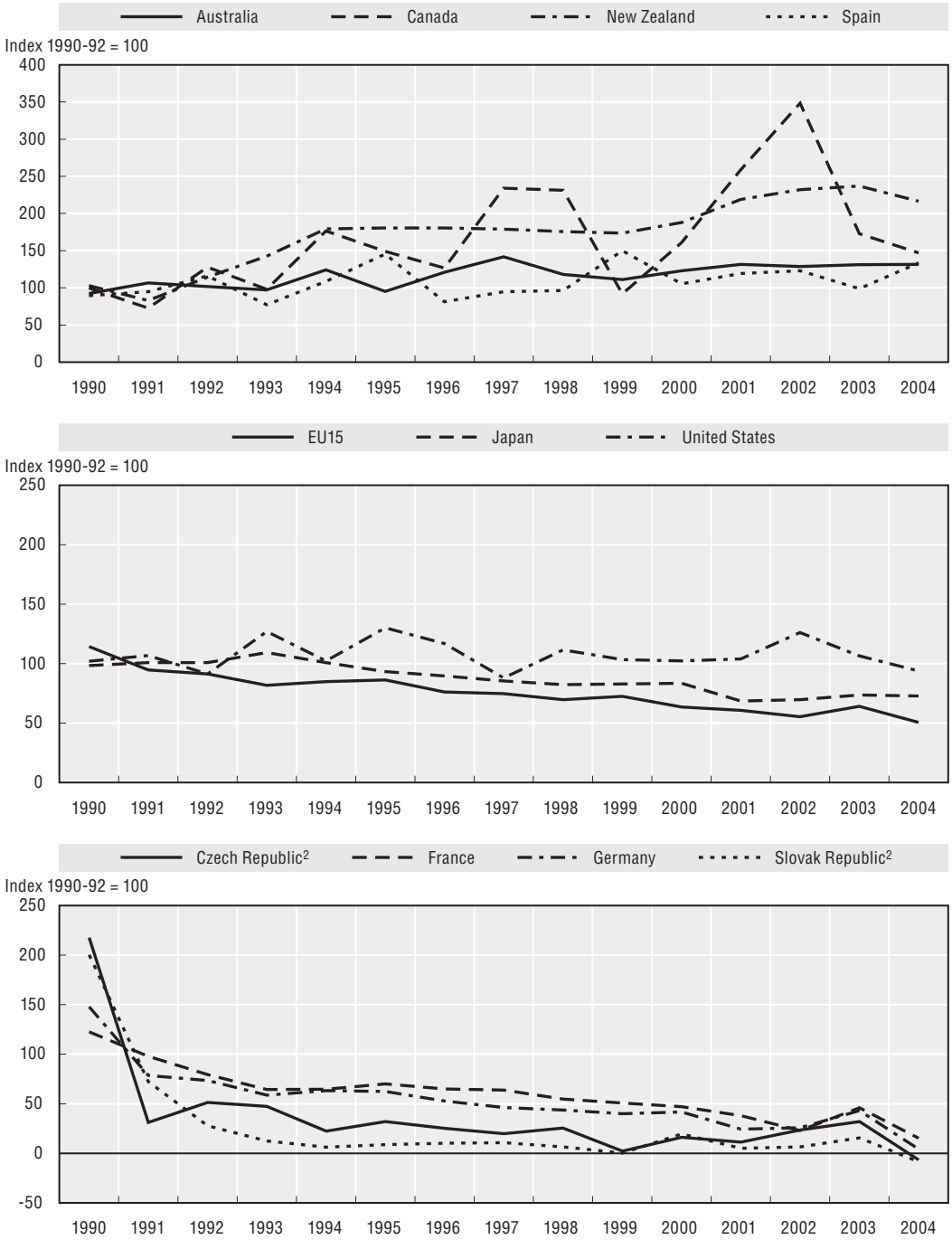
1. The gross phosphorus balance calculates the difference between the phosphorus inputs entering a farming system (*i.e.* mainly livestock manure and fertilisers) and the phosphorus outputs leaving the system (*i.e.* the uptake of phosphorus for crops and pasture production).
2. For New Zealand, change in the phosphorous balance (tonne P) is +128%.
3. For Canada, change in the phosphorous balance (tonne P) is +123%.
4. OECD excludes Hungary.
5. The phosphate (P) balance for Hungary was in deficit over the period and is not shown in the figure. But between 1990-92 to 2002-04 the P deficit was reduced, moving closer towards a balance between P inputs and P outputs. Over the period 1985-90 the Hungarian P balance was in surplus.

Source: OECD Secretariat (2007).

measures to limit the use of P_2O_5 (Johnston and Steén, 1997; USDA, 2003). Gains in P use efficiency have also been achieved through changing livestock husbandry practices, especially by altering animal feed dietary composition (OECD, 2003; 2004).

The physical properties of P in the environment are different compared to N, but ***the accumulation of P in farm soils beyond crop needs in many OECD countries is a growing environmental concern***. The retention of particulate P in soils is generally high compared

Figure 1.2.9. **Gross phosphorus balance[1] for selected OECD countries**



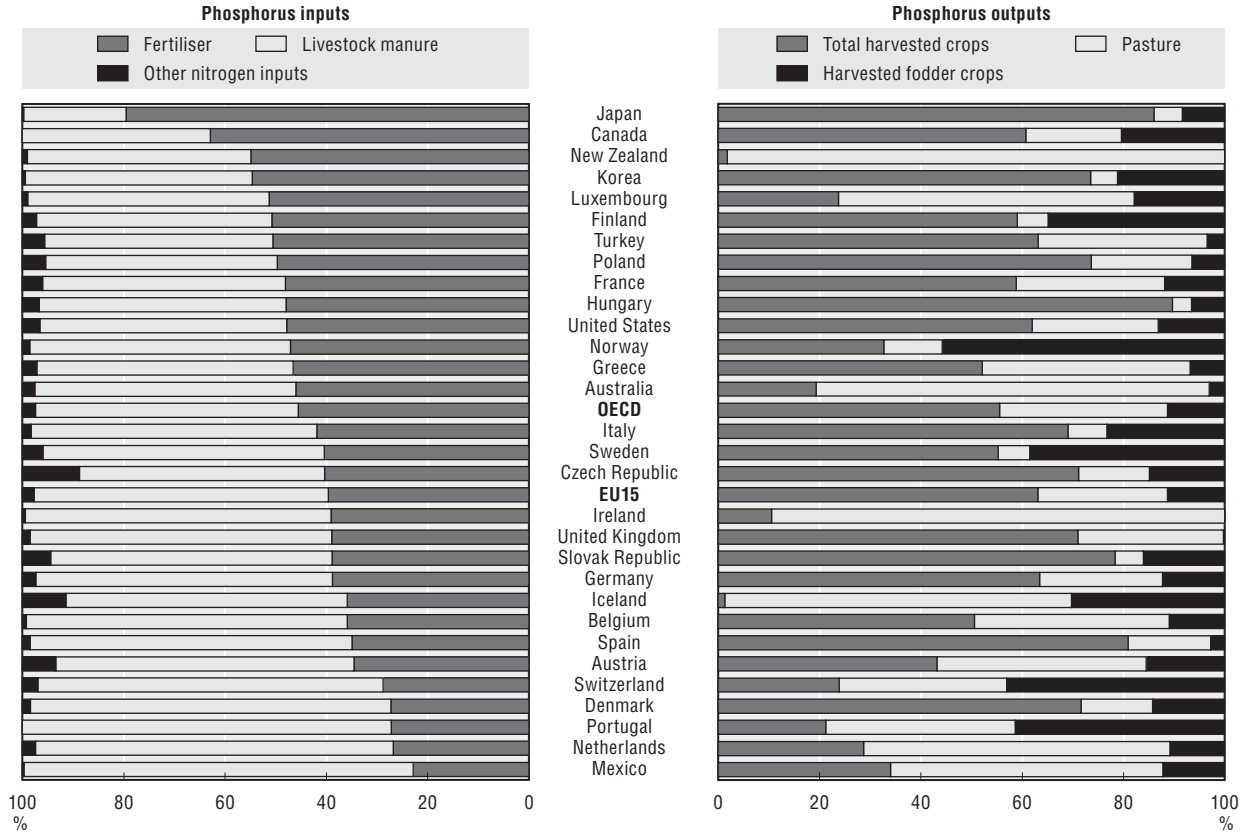
StatLink http://dx.doi.org/10.1787/286545884853

1. The gross phosphorus balance calculates the difference between the phosphorus inputs entering a farming system (*i.e.* mainly livestock manure and fertilisers) and the phosphorus outputs leaving the system (*i.e.* the uptake of phosphorus for crops and pasture production).
2. The P balances for the Czech and Slovak Republics were in deficit for 2004.

Source: OECD Secretariat (2007).

Figure 1.2.10. **Contribution of the main sources of phosphorus inputs and outputs in phosphorus balances**[1]

Average 2002-04



StatLink http://dx.doi.org/10.1787/286656618516

1. The gross phosphorus balance calculates the difference between the phosphorus inputs entering a farming system (i.e. mainly livestock manure and fertilisers) and the phosphorus outputs leaving the system (i.e. the uptake of phosphorus for crops and pasture production).

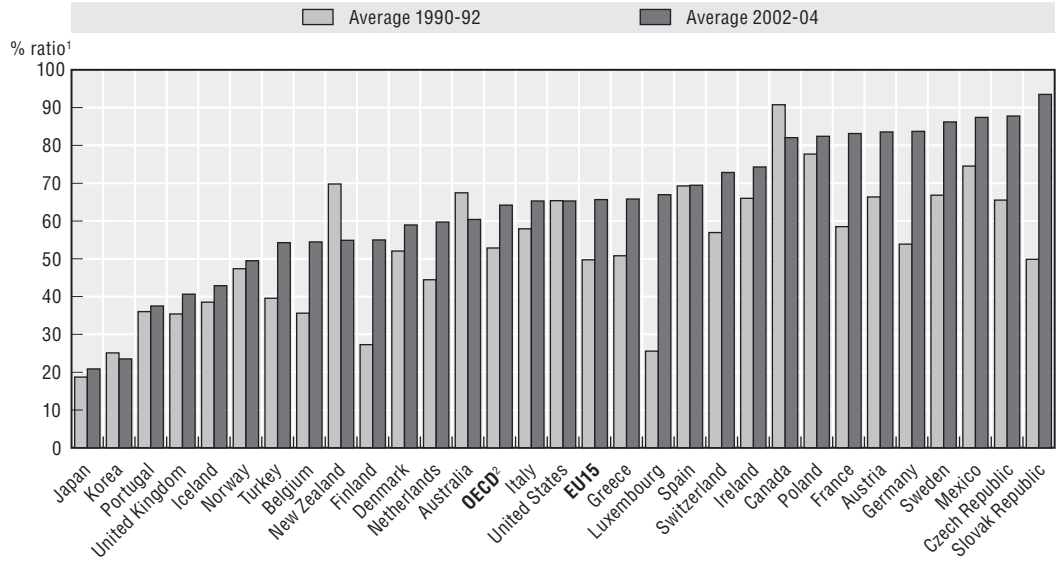
Source: OECD Secretariat (2007).

to N, hence, it is usually transported with long time lags into surface water through soil erosion rather than leaching into groundwater, unlike the more rapid transport of N from soils into water bodies (dissolved phosphorus, however, can leach more rapidly, while varying geological and soil conditions can also affect phosphorus absorption and run-off). Therefore, it is likely that there will be a considerable time lag for many countries between reductions in P surpluses leading to lower P concentrations in water supplies. Indeed, P concentrations in rivers and lakes could continue to rise for the foreseeable future, while the implications for groundwater are unclear (Section 1.6.2). In addition, the increasing uptake of low and conservation tillage practices as part of soil management practices in many countries (Section 1.9) is also aggravating P accumulation in soils, as soils are less easily eroded and hence, the P remains in the soil for longer periods. Moreover, the field application of livestock manure to balance fertiliser needs can result in the over application of phosphorus.

1.2.3. Regional (sub-national) nutrient balances

National nutrient balance indicators can mask important regional (sub-national) variations across a country, especially where more intensive agricultural production

Figure 1.2.11. **Phosphorus efficiency[1] based on phosphorus balances**



StatLink http://dx.doi.org/10.1787/286668251868

1. Phosphorus efficiency measured as the percentage ratio of total phosphorus uptake by crops and forage (tonnes) to the total phosphorus available from fertiliser, livestock manure, and other phosphorus inputs (tonnes).
2. OECD average and figure excludes Hungary, because the phosphate (P) balance for Hungary was in deficit over the period shown in the figure. But between 1990-92 to 2002-04 the P deficit was reduced moving closer toward a balance between P inputs and P outputs. Over the period 1985-90 the Hungarian P balance was in surplus.

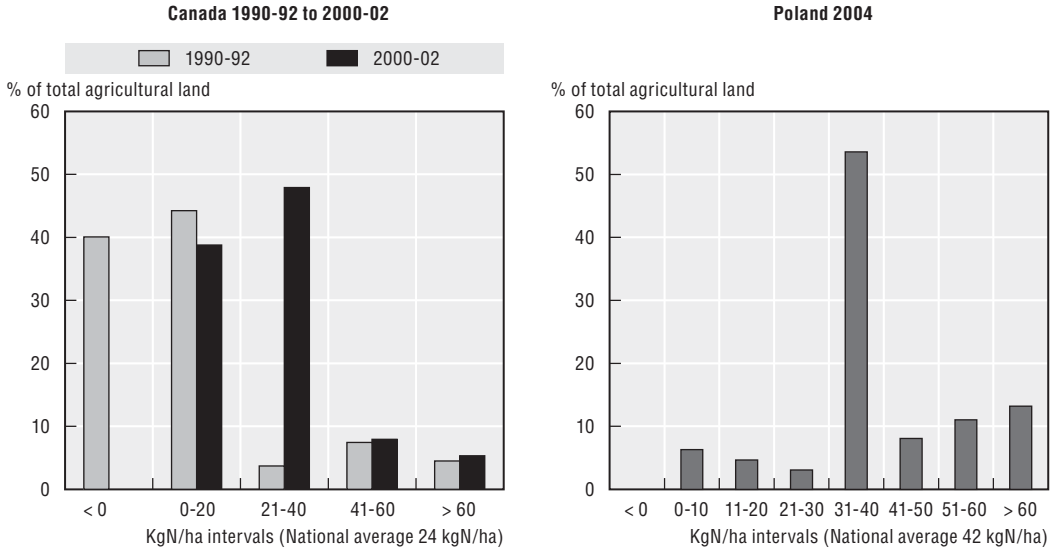
Source: OECD Secretariat (2007).

systems are spatially concentrated in a small part of the overall agricultural land area. While **Australia**, **Canada**, **Mexico**, and the **United States**, for example, are amongst OECD countries with the lowest nutrient surplus intensities (expressed as kgN/P/ha of agricultural land) there are regions within these countries where excess nutrients place a considerable pressure on the environment or where nutrient deficits are undermining crop productivity (Figures 1.2.2, 1.2.8).

In **Canada**, for example, the national N balance spatially disaggregated reveals some important developments not revealed by the average national value (Figures 1.2.2 and 1.2.12). In 1990-92 about 40% of the agricultural area had a N deficit, but a decade later this situation had improved with no land reported as having a N deficit. However, with the gradual increase in N surpluses over the 1990s there was a substantial increase in the share of farmland with a N surplus between 21-40 kgN/ha, and 10% of farmland with a surplus over 41 kgN/ha by 2000-02, compared to a national average of 28 kgN/ha, largely due to increased acreages of legume crops, higher livestock numbers and a decrease in crop output through lower yields (Lefebvre *et al.*, 2005). Similarly, in **Poland**, where the national average N surplus in 2002-04 was 46 kgN/ha, nearly one-quarter of agricultural land had a surplus greater than 50 kgN/ha (Figure 1.2.12).

The spatial variations in nutrient balances are usually explained by regional differences in farming systems. In **Italy**, for example, the Northern regions have a N surplus twelve times higher than Southern regions, due to the concentration of livestock production and maize cultivation (requiring high fertiliser inputs) in the North compared to the South (Chapter 3). Also in **Germany**, for those areas where livestock are concentrated, N surpluses are more than double the national average (Chapter 3).

Figure 1.2.12. **Spatial distribution of nitrogen balances in Canada and Poland**



StatLink http://dx.doi.org/10.1787/286670438537

Source: Lefebvre *et al.* (2005). Polish Ministry of Agriculture and Rural Development.

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1.3. PESTICIDES

KEY TRENDS

Overall OECD pesticide use has declined by 5% over the period 1990-92 to 2001-03, but marked by a large variation in trends between countries (measured in terms of the quantity of active ingredients). While pesticide use has increased in some countries, pesticides have changed over time and many of them are today less environmentally harmful. But the persistence in the environment of some older pesticides (*e.g.* DDT, atrazine and derivatives) remains a concern, although these products are now banned in some countries.

Among the ***largest users of pesticides*** across the OECD pesticide use increased in Italy, Mexico and Spain and decreased in France, Japan and the United States. Together these countries accounted for around three quarters of total OECD pesticide use in 2001-03.

For ***countries where pesticide use increased*** by over 20% (Greece, Mexico, Poland, Portugal, Turkey), this can be largely explained by the expansion in crop production (especially Mexico and Turkey) and substitution of labour for pesticides, as these countries have a relatively large but contracting agricultural labour force.

Where ***pesticide use decreased*** by over 20% (Austria, Czech Republic, Denmark, Hungary, Japan, Netherlands, Norway, Switzerland), this is related to a combination of factors which vary in importance between countries, including: for most countries a decline in crop production; the use of incentives and taxes; the adoption of pest management practices; the use of new pesticide products used in lower doses and more targeted; the expansion in organic farming; and the sharp reduction in support for agriculture in the those countries that experienced the transition to a market economy (Czech Republic and Hungary), but since around the year 2000 pesticide use for these countries has begun to rise in the period towards EU membership.

For a limited number of OECD countries indicators over the past decade reveal that in most cases ***human health and environmental risk from pesticide use are declining.*** These indicators also suggest a link between a decrease (increase) in pesticide use and decreasing (increasing) risks. Some studies show that risks are not quantified on a major share of farm land treated with pesticides.

1.3.1. Pesticide use

Indicator definition:

- Pesticide use (or sales) in terms of tonnes of active ingredients.

Concepts and interpretation

Agricultural pesticides contribute to raising agricultural productivity but also pose potential risks to human health and the environment. The risks vary greatly depending on pesticide's inherent toxicity (or hazard) and exposure. Exposure depends on a number of variables, such as the application method, the weather after application, its environmental mobility and persistence, and proximity to water courses.

This indicator provides a proxy of the potential pressure, and not actual impacts, that the use of pesticides by agriculture may place on the environment and human health. The indicator of pesticide use tracks trends over time in the overall quantity of pesticide used by agriculture (data refer to active ingredients of insecticides, fungicides, herbicides and other pesticides including plant growth regulators and rodenticides). Unlike many other indicators of pesticide use this indicator is not expressed in terms of the quantity of pesticide used per hectare of agricultural land (or crop land). This is because the application of pesticides varies widely for different crops, both within and across countries, and is sometimes used to cultivate forage crops, but limited cross country time series data exist in this regard (OECD, 2005a).

A limitation to the use of the indicator as a comparative index across countries is that the definition and coverage of pesticide use data vary across OECD countries. Only a few countries have data on actual pesticide use, but nearly all OECD countries report data on pesticide sales, which can be used as a proxy for pesticide use, although ideally it should be supported by representative samples of the use data. In **Sweden**, for example, farmer questionnaires over the 1990s show pesticide use to vary around 5% above or below sales, although in some years farmers used substantially less pesticide than was sold, such as in 1994 when a levy was introduced at the end of the year and farmers most likely stocked pesticides in anticipation of a price rise (Swedish Chemicals Inspectorate, 1999). For a number of countries pesticide use data series are incomplete, including **Australia**, **Canada** and **Iceland**. A further problem is to identify pesticide use specific to agriculture, net of uses such as forestry, gardens, and golf courses. In the **United States**, for example, agriculture accounts for 75% of pesticide use, and about 65-70% in **Belgium** (Chapter 3). The OECD, in co-operation with Eurostat, has launched a process to help improve the collection of pesticide use data (OECD, 1999).

Care is required when comparing absolute levels of pesticide use across countries, because of differences in climatic conditions and farming systems, which affect the composition and level of usage. Variability of climatic conditions (especially temperature and precipitation), may markedly alter annual pesticide use but is less important over the 14 year time series examined here, while changes in the mix of pesticides can reduce active ingredients applied but increase adverse impacts. The indicator does not recognise the differences among pesticides in their levels of toxicity, persistence and mobility. In addition, the greater use by farmers of pesticides with lower potential risk to humans and the environment because they are more narrowly targeted or degrade more rapidly, might not reveal any change in overall pesticide use trends, and possibly even show an increase. However, as revealed in Section 1.3.2 on pesticide environmental risk indicators, evidence from a limited number of OECD countries suggest correlation between a decrease (increase) in pesticide use and decreasing (increasing) risks.

As an environmental ***driving force*** the pesticide use indicator, including the indicator of the use of methyl bromide which has potential to deplete the ozone layer (Section 1.7.2), is linked to pesticide risk indicators (Section 1.3.2) and the ***state*** or presence/concentration

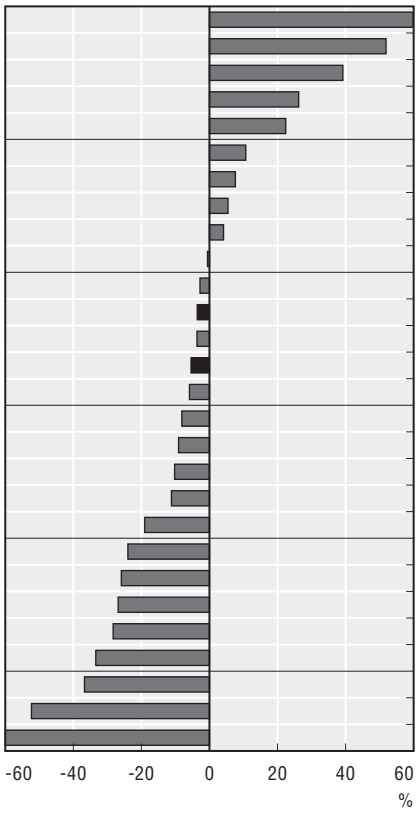
of *pesticides in water bodies* (Section 1.6.2). ***Responses*** to these changes in the state of the environment are revealed through indicators of *pest management* and *environmental farm planning*, including organic farming (Section 1.9).

Recent trends

Overall OECD pesticide use has declined by 5% over the period 1990-92 to 2001-03, but marked by a large variation in trends between countries (Figure 1.3.1). This reflects, in

Figure 1.3.1. **Pesticide use in agriculture**

Change in tonnes of active ingredients (%)



	Average[1, 2]		Change	
	1990-92[3]	2001-03	1990-92 to 2001-03	
	Tonnes		Tonnes	%
Turkey	11 967	19 128	7 161	60
Poland	6 507	9 882	3 375	52
Greece	8 337	11 605	3 268	39
Portugal	13 200	16 661	3 461	26
Mexico	31 551	38 621	7 070	22
Spain	36 849	40 783	3 933	11
Italy	79 844	85 920	6 075	8
Ireland	2 043	2 154	111	5
New Zealand	3 635	3 785	150	4
Slovak Republic	3 694	3 673	–22	–1
Sweden	1 897	1 844	–53	–3
EU15[4]	**339 515**	**327 372**	**–12 144**	**–4**
United States	325 226	313 281	–11 944	–4
OECD[5]	**867 588**	**820 826**	**–46 762**	**–5**
United Kingdom	34 060	32 064	–1 996	–6
Korea	28 097	25 821	–2 276	–8
Finland	1 727	1 570	–157	–9
France	95 281	85 531	–9 750	–10
Germany	32 629	28 982	–3 646	–11
Belgium	6 750	5 467	–1 283	–19
Austria	4 206	3 199	–1 008	–24
Norway	912	676	–236	–26
Japan	89 112	65 211	–23 900	–27
Switzerland	2 120	1 521	–600	–28
Czech Republic	6 699	4 462	–2 237	–33
Denmark	4 948	3 131	–1 817	–37
Netherlands	17 744	8 461	–9 283	–52
Hungary	18 554	7 394	–11 159	–60

StatLink http://dx.doi.org/10.1787/286683827028

Note: Caution is required in comparing trends across countries because of differences in data definitions, coverage and time periods. The following countries are not included in the figure: Australia, Canada, Iceland (time series are incomplete) and Luxembourg is included in Belgium.

1. For all countries the data represent pesticide sales except for the following countries: Korea and Mexico (national production data).
2. Pesticide use covers agriculture and non-agricultural uses (*e.g.* forestry, gardens), except for the following countries which only include agriculture: Belgium, Denmark and Sweden.
3. Data for 1990-92 average equal the: 1991-93 average for Greece and the Slovak Republic; 1993-95 average for Mexico, New Zealand and Turkey; 1995-97 average for Italy; 1996-98 average for Portugal.
4. The EU15 includes the 1996-98 average value for Portugal and OECD Secretariat estimated values for the following countries and years: Ireland: 2002 and 2003; Greece: 1991-93; Italy, Germany and Spain: 2003.
5. The OECD total includes OECD Secretariat estimated values for the following countries and years: 1990 for Greece and the Slovak Republic; 1990-92 for Mexico, New Zealand, Turkey; 2002 and 2003 for Ireland, Turkey, United States; 2003 for Germany, Mexico, Poland, Spain.

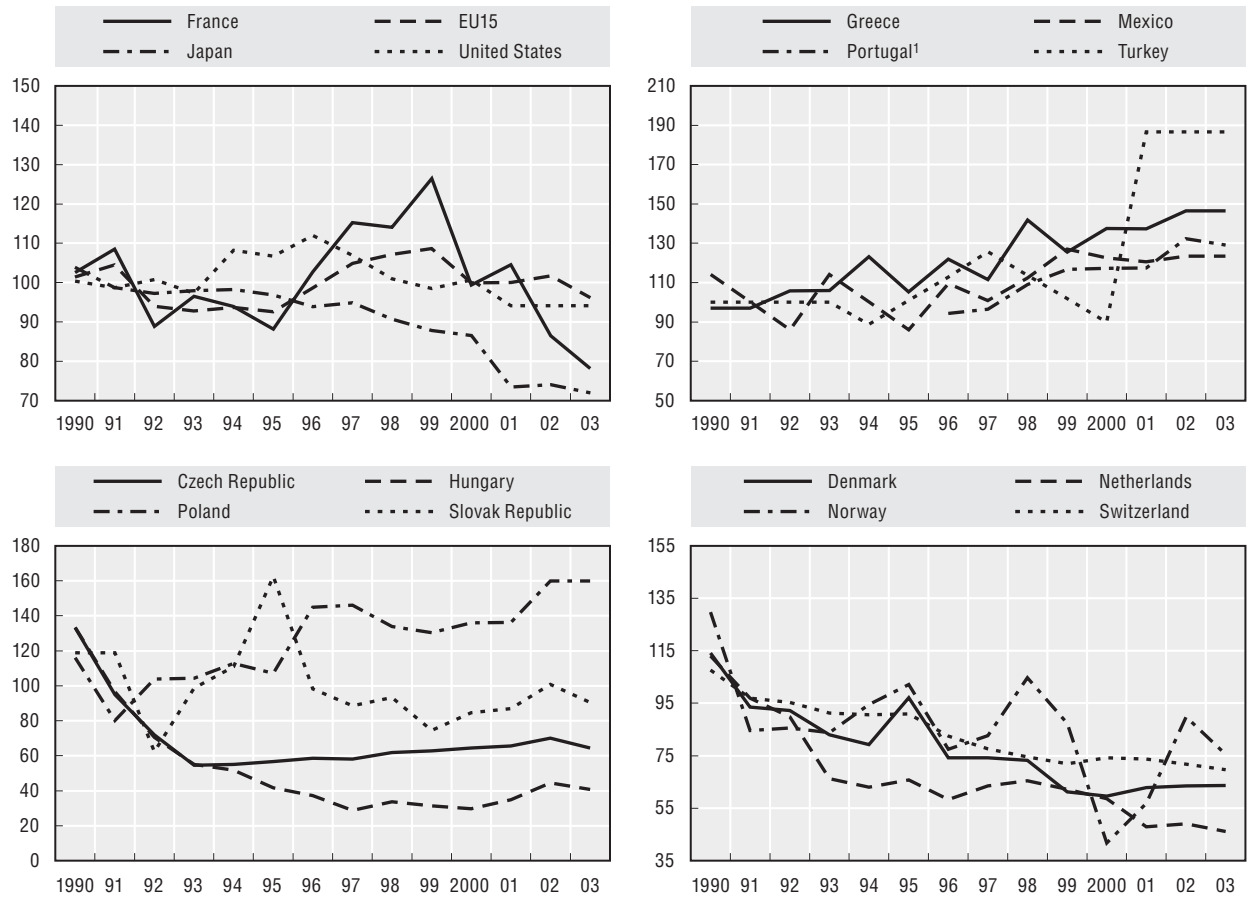
Source: OECD Environmental Data Compendium 2004, Paris, France; OECD Secretariat estimates; and national data sources.

particular, changes in the major OECD pesticide consuming countries, increasing for **Italy**, **Mexico** and **Spain**, and declining for **France**, **Japan** and the **United States**. Together, these countries account for around three-quarters of total OECD pesticide use.

Amongst ***major OECD pesticide users***, in the **United States**, the intensity of pesticide use in relation to crop production has declined, reflecting a 4% reduction in pesticide use (Figure 1.3.1) and a 13% rise in crop production over the period 1990 to 2003 (Figure 1.3.2, in Section 1.3.2). This was, in part, explained by pesticide regulations altering the mix of pesticides used by farmers, hence the rise in average pesticide prices to farmers (and in some years diminishing marginal returns to pesticide use), but also the high rate of adoption of non-chemical pest control management practices (Section 1.9). For **France** despite an overall downward trend in pesticide use the pattern was variable over the 1990s (Figure 1.3.2), although crop production expanded over this period (Figure 1.3.2, Section 1.1). In addition, French consumption of sulphuric and copper pesticide products declined by around 40% over the past decade, representing a 30% share of pesticide consumption, while there has been greater use of pesticides in lower doses. Despite the increase in **Italian** pesticide use, it has been declining over recent years, in part, because of

Figure 1.3.2. **Pesticide use for selected OECD countries**

Index 1990-92 = 100



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Note: Caution is required in comparing trends across countries because of differences in data definitions, coverage and time periods.
1. Pesticide use index 1996-98 average = 100.

Source: OECD Environmental Data Compendium 2004, Paris, France; OECD Secretariat estimates; and national data sources.

the rapid growth in organic farming (Section 1.9). In **Japan**, pesticide use declined by 27% (Figure 1.3.2), while crop production declined by nearly 19% (Figure 1.3.2, Section 1.1), suggesting greater efficiency in pesticide use. However, less than 2% of Japanese farms use non-chemical pest control methods and under 1% of the agricultural land area is farmed organically (Section 1.9).

For those ***OECD countries revealing the highest growth rates in pesticide use*** over the 1990s (*i.e.* over 20%), this can be largely explained by the substantial expansion in crop production, for example, in **Greece** and **Turkey** (Figure 1.3.2, Section 1.1). In **Poland** although overall crop production declined the growth in horticultural output and yields plus the substitution of labour for pesticide inputs, especially since the mid-1990s, resulted in a major increase in pesticide use (Figure 1.3.2). For **Portugal** the rise in pesticide use is largely due to the growth in the horticultural sector, although the productivity of pesticide use per hectare has improved. While pesticide use volume data are not available for **Australia** given the rapid growth in crop production over the 1990s (Figure 1.3.2, Section 1.1), especially horticultural products (*e.g.* viticulture), it is likely that pesticide use has also risen.

A significant reduction in pesticide use occurred for the **Czech** and **Slovak Republics**, **Hungary** and **Poland in the early 1990s**, largely explained by their transition to a market economy (Figure 1.3.2), which led to: a collapse in agricultural support levels; the elimination of subsidies for pesticides; and increasing debt levels in the farm sector limiting farmers' ability to purchase inputs (OECD, 1998). However, in the more recent transition period towards EU membership, especially since around the year 2000, pesticide use for these countries has begun to rise (Figure 1.3.2).

For some other OECD countries where the reductions in pesticide use over the past 10 years have been significant (*i.e.* over 20%, Figure 1.3.2), this can be explained by a combination of factors. Frequently crop production has declined (*e.g.* **Denmark** and **Switzerland**); targets have been set to reduce usage (*e.g.* **Denmark**, the **Netherlands**); and taxes applied to dissuade pesticide use (*e.g.* **Denmark** and **Norway**). It can be difficult, however, to disentangle the effects of pesticide taxes from other policy effects on pesticide use (Pearce, 2003). Pesticide reduction has also been linked, in some countries, to the increasing area of crops under some form of pest management control, such as using less but better targeted pesticides and growing pest resistant crop varieties (*e.g.* **Austria**, **Norway** and **Switzerland**, Section 1.9). Also the rapid expansion in organic farming for some countries has reduced demand for pesticides. In **Austria, Denmark, Finland** and **Switzerland**, over 6% of the agricultural area is now under organic farming (Section 1.9).

1.3.2. Pesticide risk indicators

Indicator definition:

- Risk of damage to terrestrial and aquatic environments, and human health from pesticide toxicity and exposure.

Concepts and interpretation

A change in pesticide use may not be equivalent to a change in the associated risks because of the great variance in risks posed by different products. Changes in the herbicide

market seen in the 1980s provide an illustration, as new herbicide products came on to the market that were much more biologically active than their predecessors and were therefore used in much smaller quantities. Pesticide use indicators for this period showed a substantial reduction in herbicide use. By contrast, risk indicators might show no change, or perhaps even an increase, in the environmental and human health risks associated with herbicide use. The greater use of pesticides which carry a lower risk to humans and the environment because they are more narrowly and accurately targeted or degrade more rapidly, might also not reveal any change in overall pesticide use trends, and possibly even an increase.

The OECD Pesticide Programme, which started in 1997, completed a project that analysed and compared six models that can be used to derive pesticide risk indicators (OECD, 2005b). All of the models evaluated in the OECD project are designed to report pesticide risk trends at the national level and five of the six models use the same basic formula:

exposure/toxicity (or toxicity/exposure) × total amount used

The sixth model uses a similar basic formula:

(amount sold/dose)/total arable land treated

The pesticide risk indicator models evaluated in the OECD project share a similar underlying structure. However, the models differ in how they estimate exposure and in how they weight different variables. These differences reflect the circumstances and understanding of risk in different countries. In this sense, pilot testing of these indicators conducted in the OECD project has provided information on evaluating possible widespread use of these indicators (OECD, 2005b).

Lack of data is one of the most important obstacles to using pesticide risk indicators (OECD, 2005b). Data on pesticide properties are generally available in national pesticide registration files, but the OECD project found that data in some areas, most notably long-term (chronic) toxicity, are incomplete. Moreover, even for short-term (acute) toxicity, the data show widely varying values. The OECD project concluded that use of a consistent approach from year to year was important for always selecting the highest, lowest, or average value, for example. Data on pesticide use (*e.g.* from farmer surveys), rather than sales data, are also lacking in many countries, although momentum is building to collect such data (Section 1.3.1). It was also concluded that distributing the national sales of a given pesticide among various crops on which it is registered (as most indicators require) can be difficult and time-consuming, and may require using a 3-year rolling average and limit analysis to major pesticides or crops to keep the project viable.

Recent trends

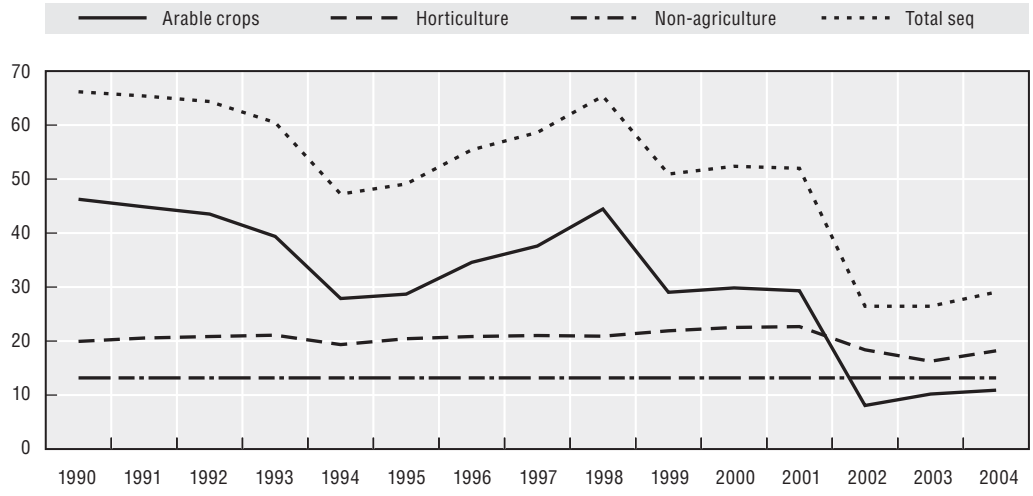
Evidence from a limited number of OECD countries shows that human health and environmental risk from pesticide use has declined over the past decade in most cases. These indicators also suggest a link between a decrease (increase) in pesticide use and decreasing (increasing) risks, however, some studies show that risks are not quantified on a major share of farm land treated with pesticides. These conclusions are drawn from information on pesticide risk indicator trends reported by: **Denmark, Netherlands, Norway** for risks to terrestrial organisms; **Belgium** and the **United Kingdom** for aquatic organisms; and **Germany** for both terrestrial and aquatic organisms (OECD, 2003). In addition, **Sweden** has completed a national project that has developed two pesticide risk indicators with the main objective to monitor the impact of pesticide policies nationally

and follow up the trends at individual farm level. It should be noted, however, that these country examples cannot be used for cross country comparisons as the indices are relative not absolute values.

Belgium. A risk assessment of the use of pesticides for aquatic species has been made for Belgium (de Smet *et al.*, 2005). Pesticide use is weighted according to eco-toxicity and persistence in the environment because use in kilogrammes of active substances does not sufficiently represent environmental risks. The pressure on aquatic ecosystems, to be viewed as risk to aquatic species, is expressed as the sum of the spread (dispersion) equivalents (Σ Seq). The aquatic risk index (Σ Seq) for agriculture declined by 55% between 1990 and 2004 (Figure 1.3.3), *inter alia* because of the decreasing use of lindane (an insecticide) and paraquat (a herbicide). The Flemish Environmental Policy Plan, sets a 50 % reduction goal for Σ Seq in 2005 compared to 1990 for all pesticide users, including agriculture. With the prohibition of lindane in 2001 and some 40 other pesticide active ingredients (compared to an authorised total of 375) from 2003, the 50% reduction goal has been achieved since the sharp decline in 2002 of Σ Seq, especially that of arable crops (de Smet *et al.*, 2005).

Figure 1.3.3. **Belgium: Risk for aquatic species due to use of pesticides in arable land, horticulture and outside of agriculture**

Spreads equivalents in billions

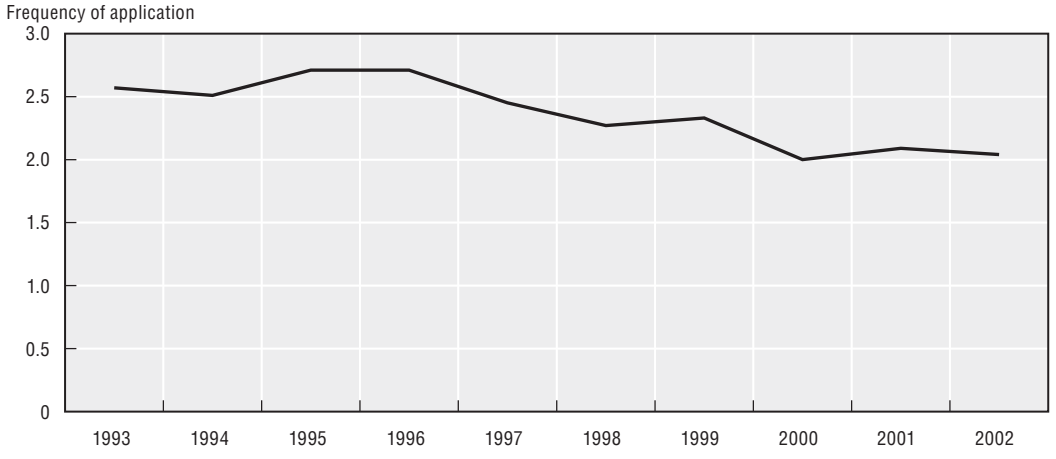


StatLink http://dx.doi.org/10.1787/286707848675

Source: Department of Crop Protection, University of Gent.

Denmark. The Danish indicator of frequency application, an indicator of spraying intensity and overall environmental impact of pesticides, has declined since 1993 (Figure 1.3.4), in parallel to a large reduction in pesticide use (Figure 1.3.2). The Danish Load Index is also used as a risk indicator, and reflects changes in inherent properties of pesticides such as toxicity to fish, birds, mammals, which may not be directly reflected in the Frequency of Application Index. Denmark has used the Load Index to track changes in pesticide load on a given organism as a result of the re-evaluation of pesticides carried out in the 1990s. The Load index showed a clear reduction with respect to acute and chronic toxicity for mammals, while values also declined for acute toxicity for birds and crustaceans, but for fish remained unchanged.

Figure 1.3.4. **Denmark: The annual trend in frequency of pesticide application**



StatLink http://dx.doi.org/10.1787/286736745071

Source: Gravesen (2003).

Germany. In Germany, the pesticide risk indicator model SYNOPS is used to assess and to analyse the environmental risk caused by pesticide use in agriculture (Table 1.3.1). To characterize the status quo, the risk potential (without consideration of risk mitigation measures as required by pesticide registration authority) of the mostly recently used pesticides for the crop years 2000, 2002, and 2004, is compared with corresponding risk indices caused by pesticides used in 1987. Table 1.3.1 shows the change of risk indices in per cent from the base year 1987 = 100.

Table 1.3.1. **Germany: Percentage risk indices**

1987 to 2004 (1987 = 100)

	Acute risk (%)					Chronic risk (%)			
	Earthworms	Daphnia	Fish	Algae	Bees	Earthworms	Daphnia	Fish	Algae
Herbicides	37	44	45	36	46	31	47	51	35
Fungicides	60	33	66	131	55	81	22	52	76
Insecticides	11	8	36	7	14	20	24	93	6

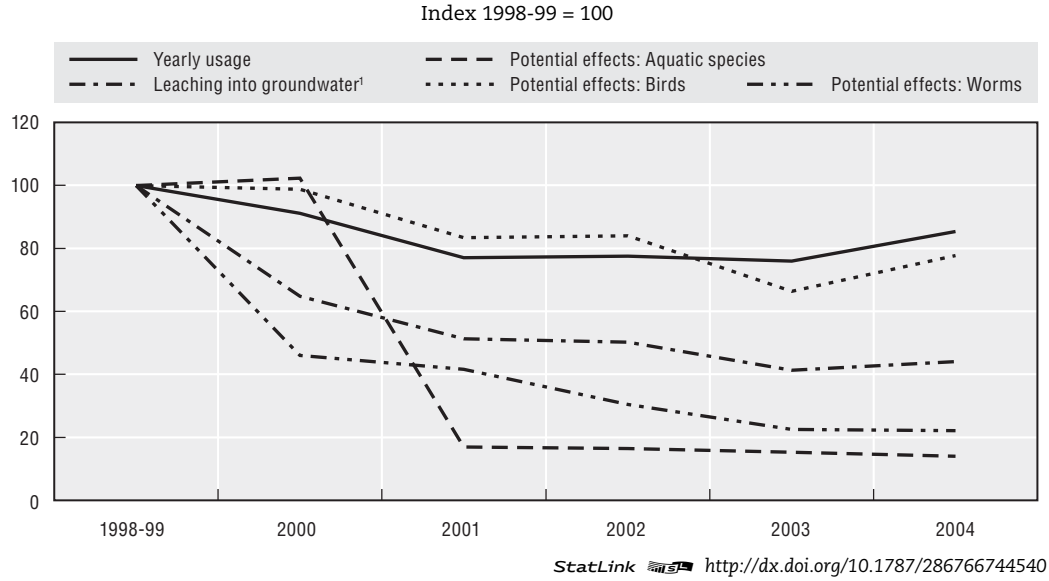
StatLink http://dx.doi.org/10.1787/301374302758

Source: Federal Biological Research Centre for Agriculture and Forestry, Berlin-Braunschweig.

To describe the status quo of the intensity of pesticide use in agricultural practice, the project NEPTUN was established in Germany. NEPTUN is a randomised and regionally stratified survey based on voluntary co-operation with farmers. The following crops were surveyed: arable crops (1999/2000), hops (2001), orchards (2001 and 2004), and vineyards (2003). In the future additional crops will be surveyed. *Inter alia* the survey results facilitate the calculation of normalised application indices for crops in terms of the number of pesticides used in a crop and normalised to the area treated and the ratio between the application dose used and the registered application dose. NEPTUN results also feed the risk indicator model SYNOPS and serve to analyse regional differences in the risk potential caused by the different use of pesticide as well as the different application conditions (landscape attributes) and crops.

Netherlands. The trend of pesticide risks for groundwater and organisms, developed in the Netherlands, was calculated for the period 1998-99 to 2004 (Figure 1.3.5). The yearly usage of pesticides shows a gradual decline over the entire period, except for a small increase in 2004 (Figure 1.3.2). The indicator values for potential chronic *toxic effects on birds and worms* also show a gradual decrease over the entire period. This decrease is somewhat larger than would be expected on the basis of the reduction of pesticide usage, which reflects the disappearance of some of the more toxic pesticide compounds from the market. Groundwater leaching and the potential chronic toxic effects towards *aquatic species*, after rising in 2000, showed a gradual decline in common with the other indicator scores (Figure 1.3.5).

Figure 1.3.5. **The Netherlands: Potential chronic effects scores for aquatic and terrestrial organisms and leaching into groundwater**



StatLink http://dx.doi.org/10.1787/286766744540

1. Groundwater leaching index is with reference to drinking water limits.

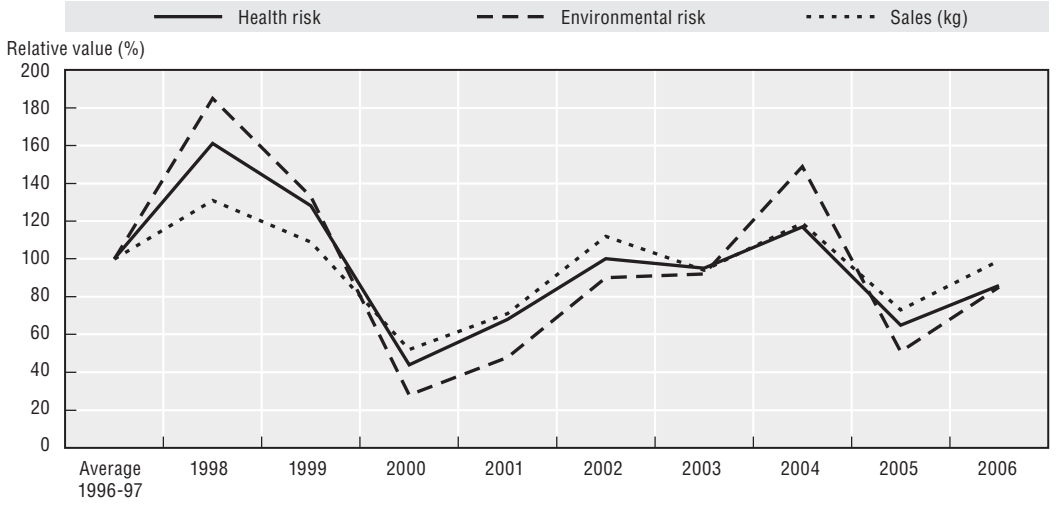
Source: Deneer *et al.* (2003) and RIVM.

Norway. The Norwegian environmental risk indicator is based on the toxicity of each pesticide to non-target species (birds, earthworms, bees and aquatic species). In addition, it takes into account leaching, persistence, bioaccumulation and formulation type, and uses scores (weighting factors) that are added together and multiplied (scaled) by the treated area. Since the sales data for the years 1996 to 2006 are strongly influenced by other factors than change in actual use (stockpiling to avoid increased taxes), it is difficult to use this as a basis for conclusions about risk. Compared to the sales curve, the risk indicators showed higher values for 1998 and 1999, which corresponds to the stockpiling of pesticides with the highest health and environmental risk (highest tax classes). For succeeding years the risk values are lower, reflecting both reduced imports/sales and less risk associated with the pesticides purchased by farmers (Figure 1.3.6).

A working group in Norway submitted, in 2003, its final evaluation of the *Action Plan for Pesticide Risk Reduction (1998-2002)* including an evaluation of the pesticide levy system, as this was one of the measures in the Plan. Comparing the average for 1996-97 with that of 2001-02, there was a slight drop in pesticide sales (8%), but a marked reduction in the risk to health (33%) and the environment (37%).

Figure 1.3.6. **Norway: Trends of health risk, environmental risk and sales of pesticides**

Average 1996-97 = 100



StatLink http://dx.doi.org/10.1787/286810015086

Source: The Norwegian Food Safety Authority.

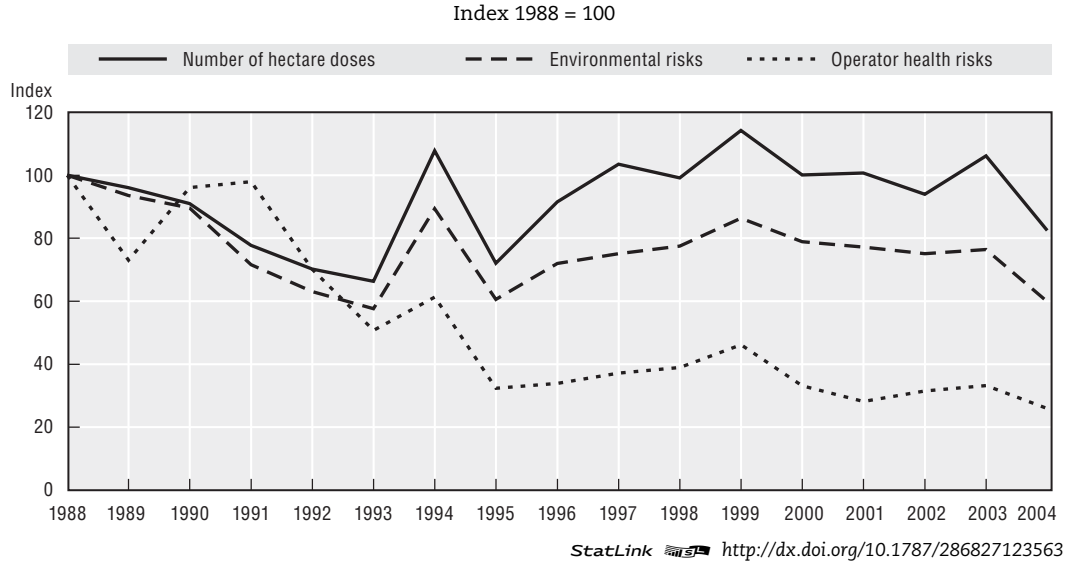
Although care is required not to place too much weight on these data, the trend is still clear with a marked reduction in risk during the period of the Action Plan, both in terms of health and environmental risks. Changes to the pesticide levy system from 1999, with differentiated charges conditional on health and environmental properties, seems to have had the desired effect of moving users away from using hazardous pesticides to less harmful preparations.

Even though trends are moving in a positive direction, the results from the monitoring programmes on foodstuffs and the environment indicate that the situation is still not entirely satisfactory. Between 2000 and 2006, pesticide sales steadily rose (allowing for some annual fluctuations) and as a consequence health and environmental risks also increased (Figure 1.3.6). The evaluation group emphasises the need for targeted efforts to further reduce the risk of damage to health and the environment through the use of pesticides and advises a new *Action Plan for Pesticide Risk Reduction* (2004-08) built on the equivalent main elements contained in the previous Plan.

Sweden. Sweden has developed two pesticide risk indicator systems to monitor the impact of pesticide risk reduction policies: at the national level (PRI-Nation) and at the individual farm level (PRI-Farm). Both models are based on the same approach, where data on hazard and exposure are scored based on field data where available, expert judgements or policy assessments, combined with data on use intensity (Bergkvist; 2004). Both PRI-Nation and PRI-Farm comprise two indicators that cover environmental risks and farm operator health risks respectively. The results are aggregated to a single score for each substance or treatment with the intention to indicate environmental and operator health risks respectively.

For PRI-Nation, Figure 1.3.7 indicates a clear downward trend in both environmental and operator health risks, while pesticide use intensity (*i.e.* the total number of doses per hectare) has been near stable since 1997. These improvements in pesticide risks are largely due to farm advisory services focusing on integrated and need based crop protection, successful regulatory activities and also pesticide product development (Bergkvist; 2004; Swedish Chemicals Inspectorate, 1999).

Figure 1.3.7. **Sweden: National level pesticide risk indicators and the number of hectare doses**

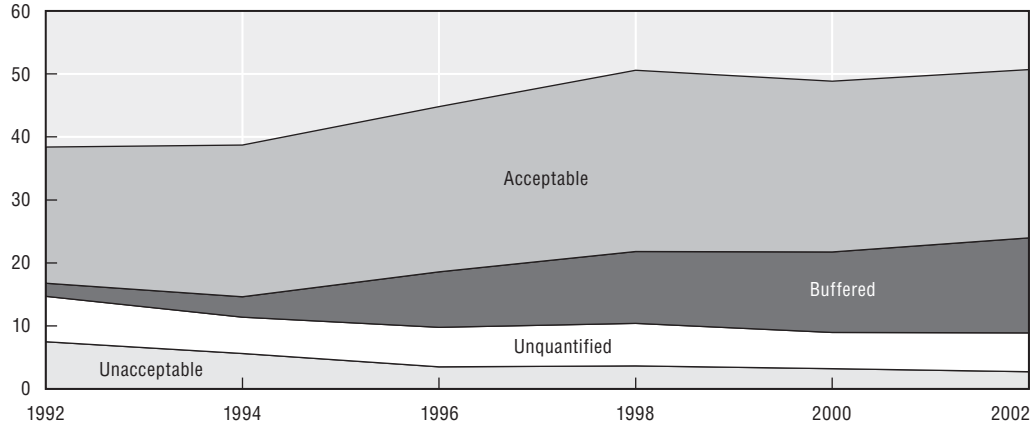


StatLink http://dx.doi.org/10.1787/286827123563

Source: Bergkvist, 2005.

United Kingdom. The United Kingdom has developed a "threshold" approach, which makes use of risk to aquatic life thresholds used in the regulatory assessment of pesticides. The threshold approach divides the total area of pesticide applications into different risk categories, and shows how these change over time. The results shown in Figure 1.3.8 indicate that the total area of pesticide applications increased steadily from 1992 to 2002. Over half of the area on which pesticides were applied qualifies as "acceptable risk", based on EU criteria. Since the early 1990s, if complied with, buffer zones are making an increasing contribution to reducing risks, but a large area is treated with pesticides for which the risk is unquantified and needs further assessment.

Figure 1.3.8. **United Kingdom (England and Wales): Total area of pesticide applications**



StatLink http://dx.doi.org/10.1787/286851221782

Notes: ***Total area of pesticide applications*** for arable crops in England and Wales was obtained from the UK Pesticide Usage Survey. Multiple applications are added together, *e.g.* spraying one hectare with two pesticides counts as two spray hectares.

Acceptable risk: Pesticides either have toxicity-exposure ratios (TERs) for fish, daphnia and algae which fall within the thresholds defined in EU regulations, or have been subjected to a higher-tier assessment which shows they pose no unacceptable risks.

Buffered: Pesticides subject to buffer zones have TERs outside the EU thresholds, but have been assessed by the UK Pesticides Safety Directorate as posing acceptable risk provided no spray is applied within 6 metres of water bodies such as streams, ponds and ditches.

Unacceptable risk: Refers to the use of pesticides which have been shown by higher-tier assessment to pose unacceptable risk. In practice this applies to the historical use, without buffer zones, of pesticides now considered to require them.

Unquantified risk: Refers to pesticides which have TERs outside the EU thresholds, and have not yet been assessed under current regulations, or lack the necessary data for calculating TERs. It is therefore not known whether the risk they pose is acceptable or unacceptable by modern standards.

Source: Hart *et al.* (2003).

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1.4. ENERGY

KEY TRENDS

OECD wide, on-farm energy consumption increased by 3% compared to 19% for all sectors (1990-92 to 2002-04), but nearly a half of the member countries reduced their energy consumption. The share of farming in total OECD energy consumption is around 2% (2002-04). While the EU15 and the United States accounted for nearly 60% of OECD on-farm energy consumption, their growth in consumption has been below the OECD average.

Much of the expansion in on-farm energy consumption has occurred in Australia, Korea, Mexico, New Zealand Poland, Spain and Turkey, which by 2002-04 accounted for about a quarter of OECD on-farm energy consumption. The growth in energy consumption in these countries is largely explained by a combination of rising agricultural production over the 1990s, continued expansion of mechanisation and increasing machinery power, and the substitution of labour for machinery, although the relative importance of these different factors varied between countries.

The Czech and Slovak Republics and Hungary experienced a significant reduction in agricultural production and on-farm energy consumption, as a consequence of the removal of farm and input subsidies, in the transition from a centrally planned to a market economy. But since around the year 2000 on-farm energy consumption for these countries has begun to stabilise or rise slightly in the period towards EU membership.

Petrol and diesel, are the ***main sources of on-farm energy consumption*** in most OECD countries, accounting for over 50% in both the EU15 and the United States. With the expansion in renewable energy production across an increasing number of countries, its share in on-farm energy consumption, though small, has risen, notably in Austria, Denmark and Finland. There has also been a trend in many countries toward an increasing share of electricity in on-farm energy consumption to power machinery, partly reflecting the substitution of labour for machinery.

Trends in on-farm energy consumption largely reflect farmer response to energy prices, agricultural energy subsidies, and energy consumption efficiency. Real crude oil prices showed a declining trend from 1990 up to 1997-98, after which prices began to rise. OECD on-farm energy consumption increased up to the mid-1990s followed by a decline to 2004.

Agricultural energy subsidies, mainly for fuel, are widespread across OECD countries, and are usually provided by reducing the standard rate of fuel tax for on-farm consumption, but also for power and heat in some cases. These subsidies act as a disincentive to reduce on-farm energy consumption and use energy more efficiently, and also, by stimulating higher energy use, put pressure on the environment by leading to increased greenhouse gas emissions and other air pollutants from agriculture.

Improvements in on-farm energy consumption efficiency – on-farm energy consumption growing at a lower rate than growth in farm production – are apparent for many countries. For example, on-farm energy consumption declined in Austria, Denmark and France, despite an increase in agricultural production. In Canada, on-farm energy efficiency decreased slightly over the 1990s due to an increase in diesel fuel consumption (replacing petrol), and an increase in fertiliser use, with a corresponding decrease in high energy output crop production.

Indicator definition:

- Direct on-farm energy consumption in national total energy consumption.

Concepts and interpretation

Agriculture can play a double role in relation to energy, both as a consumer and producer of energy. Farming is a direct energy consumer for crop and livestock production, and also consumes energy indirectly in terms of the energy required to produce fertilisers, pesticides, machinery and other inputs. But agriculture can also produce energy and raw materials through biomass production as a feedstock to supply bioenergy and biomaterials (*e.g.* cotton, plastics), which includes in the case of bioenergy, biofuels, such as bioethanol, and biopower in the form of heat and electricity (OECD, 2004).

Purchased energy is essential to provide power for modern agricultural production systems. From an environmental perspective, however, agricultural energy consumption can lead to air pollution through emission of greenhouse gases (principally carbon dioxide, CO_2); emissions of nitrogen oxides (NO_x), sulphur dioxide (SO_2), particulate matter; as well as emissions of ozone depleting precursors. While energy produced from fossil fuel combustion is non-renewable, renewable energy derived from agricultural biomass feedstock has the potential to provide environmental benefits, for example, some feedstocks are carbon neutral from a climate change perspective (OECD, 2004).

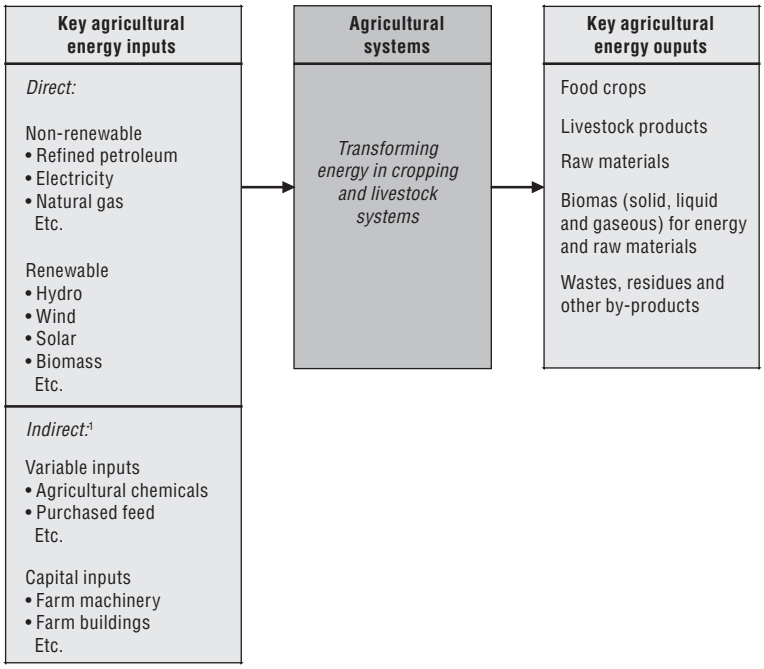
Energy indicators have been in use for some time both at the national and international level (Cleveland, 1995; EEA, 2005; IEA, 2002; OECD, 2002; Wells, 2001; World Bank, 2002). A simple model for energy consumption in agriculture is shown in Figure 1.4.1. *Direct* on-farm energy consumption by primary agriculture covers consumption for irrigation, drying, horticulture, machinery and livestock housing. *Indirect* energy, on the other hand, refers to energy consumption for the production, packaging and transport of fertilisers and pesticides and in the production of farm machinery.

The OECD agricultural energy indicator in this section focuses on *direct* on-farm energy consumption by primary agriculture, and draws on data and definition of energy consumption from the International Energy Agency (IEA, 2004). A limitation of the indicator for most countries, concerns the difficulty of separating agricultural energy consumption data from data for energy consumption by hunting, forestry and fisheries. Also, the extent to which farm household consumption is included in the data is unknown. Therefore, caution is required when comparing agricultural energy consumption trends across countries.

The indicator here makes no distinction between either the sources of energy consumption by agriculture, non-renewable or renewable, or the production of energy from agricultural biomass feedstocks. The IEA is currently in the process of collecting information on renewable energy by various sectors, including agriculture, as part of its focus on renewable energy supply and demand. Hence, in the future it may be possible to develop the agricultural energy consumption indicator to take account of agriculture's production and consumption of renewable energy.

Direct on-farm energy consumption acts primarily as a ***driving force*** on the ***state*** of climate change through greenhouse gas emissions (Section 1.7.3), although there are secondary environmental concerns related to air pollution from burning fossil fuels, such

Figure 1.4.1. **Simplified energy "model" of an agricultural system**



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1. Indirect energy consumption is not included in the indicator covered in this section.

Source: OECD Secretariat, 2007, adapted from Uhlin, 1999; and Wells, 2001.

as particulate matter and ozone depletion. Agriculture's ***response*** to reducing energy consumption is largely through improving energy efficiency and also substituting the consumption of non-renewable for renewable energy sources.

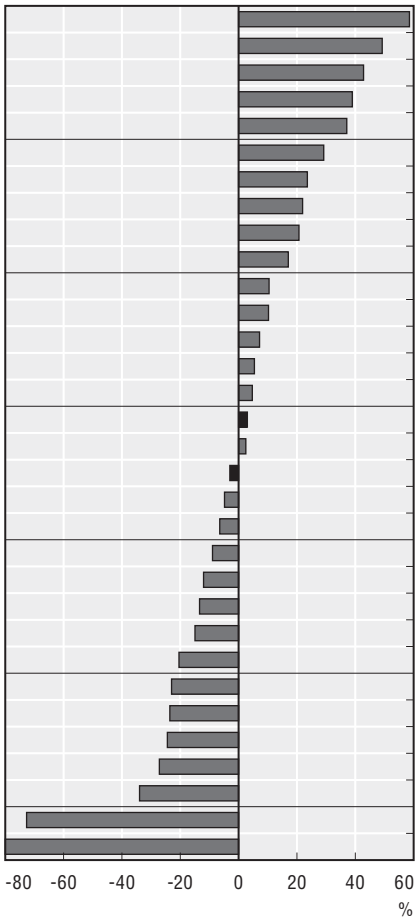
Recent trends

OECD on-farm energy consumption over the period 1990-92 to 2002-04 increased by 3% compared to 19% for all sectors, but nearly a half of the member countries reduced their energy consumption (Figure 1.4.2). But the share of agriculture in total OECD energy consumption was only 2% in 2002-04 (Figure 1.4.2). While the **EU15** and the **United States** accounted for nearly 60% of OECD on-farm energy consumption, their change in energy consumption (2002-04) has been below the OECD average at –3% and +2% respectively during 1990 to 2004 (Figure 1.4.3).

Instead much of the expansion in OECD on-farm energy consumption has occurred in **Australia, Korea, Mexico, Poland, Spain** and **Turkey**, which by 2002-04 accounted for about a quarter of OECD on-farm energy consumption (Figures 1.4.2, 1.4.3). The growth in energy consumption in these countries is largely explained by a combination of rising agricultural production over the 1990s, continued expansion of mechanisation and increasing machinery power, and the substitution of labour for machinery, although the relative importance of these different factors varied between countries (Figures 1.4.2 and 1.4.4; Hatirli *et al.*, 2004; OECD, 1999).

On-farm energy consumption may also be linked in some countries to the requirement for farmers to field spread manure in an effort to reduce nutrient surpluses, necessitating greater use of farm machinery (*e.g.* **Netherlands**). In other cases the rapid expansion of organic production may have required more mechanical weeding raising energy demand.

Figure 1.4.2. **Direct on-farm energy consumption**[1]



	Average[1]		Change in on-farm energy consumption		Change in total energy consumption	Share in national total energy consumption	Share in total OECD on-farm energy consumption
	1990-92	2002-04	1990-92 to 2002-04		1990-92 to 2002-04	2002-04	2002-04
	Ktoe[2]		Ktoe[2]	%	%		
Turkey	1 997	3 167	1 170	59	44	5	5
Australia	1 339	1 998	659	49	25	3	3
Korea	1 878	2 682	805	43	96	2	4
Spain[3]	1 818	2 525	707	39	54	3	4
Ireland	222	304	82	37	53	3	0
Poland	3 454	4 463	1 009	29	–4	8	7
Norway	657	812	155	24	17	4	1
New Zealand	261	318	57	22	38	2	0
Mexico	2 299	2 774	476	21	10	3	4
Luxembourg	13	15	2	17	31	0	0
Italy	3 011	3 326	315	10	13	2	5
Greece	1 075	1 186	110	10	36	6	2
Iceland	287	308	21	7	40	13	0
Canada	3 408	3 593	184	5	22	2	5
Netherlands	3 752	3 927	175	5	16	6	6
OECD	**63 262**	**65 259**	**1 997**	**3**	**19**	**2**	**100**
United States	15 007	15 377	370	2	20	1	23
EU15	**22 568**	**21 927**	**–640**	**–3**	**13**	**2**	**34**
Japan	6 968	6 629	–339	–5	19	2	10
Belgium[4]	850	795	–55	–6	20	2	1
France	3 313	3 017	–297	–9	11	2	5
Finland	870	765	–104	–12	18	3	1
Austria	715	619	–96	–13	29	2	1
Sweden	653	554	–99	–15	10	2	1
Germany	3 349	2 664	–686	–20	1	1	4
Portugal	586	452	–135	–23	50	2	1
United Kingdom	1 309	1 000	–309	–24	8	1	2
Denmark	1 031	779	–252	–24	7	5	1
Switzerland	203	148	–55	–27	6	1	0
Hungary	956	631	–325	–34	–2	3	1
Slovak Republic	666	182	–484	–73	–21	2	0
Czech Republic[5]	1 314	250	–1 064	–81	–16	1	0

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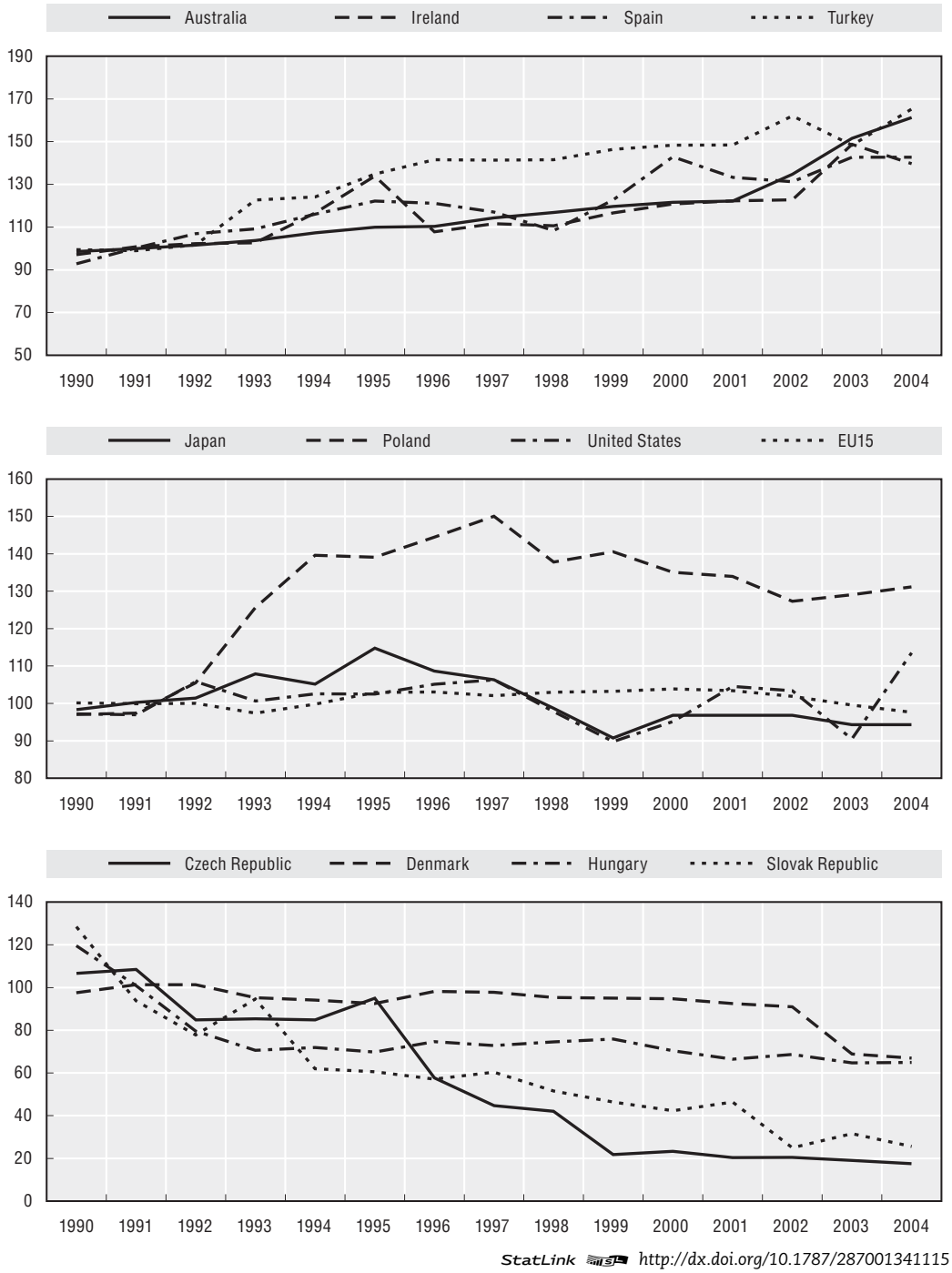
1. Data cover total on-farm energy consumption by primary agriculture (for irrigation, drying, horticulture, machinery and livestock housing), forestry, fishing and hunting, except Belgium, Italy, Switzerland and the United Kingdom, where data only include agriculture.
2. Ktoe equals thousand tonnes of oil equivalent.
3. Data energy are drawn from national sources. Data for the year 2004 refer to the year 2003.
4. The average 1990-92 and 2002-04 covers 1990 and 1999-01, respectively.
5. For the Czech Republic, the change in on-farm energy use is –81%.

Source: IEA (2006); national data for Portugal, Spain and Sweden.

For those countries that experienced the transition from a centrally planned to a market economy, such as the **Czech Republic**, **Hungary** and **Slovak Republic**, they experienced a significant reduction in agricultural production and on-farm energy consumption, as a consequence of the removal of output and input-linked subsidies. But since around the year 2000 on-farm energy consumption for these countries has begun to stabilise or rise slightly in the period towards EU membership (Figure 1.4.3). In other countries experiencing a marked reduction in on-farm energy consumption (*e.g.* **Germany**, the **United Kingdom**) this was to a large extent due to declining levels of agricultural

Figure 1.4.3. **Direct on-farm energy consumption[1] for selected OECD countries**

1990-92 = 100



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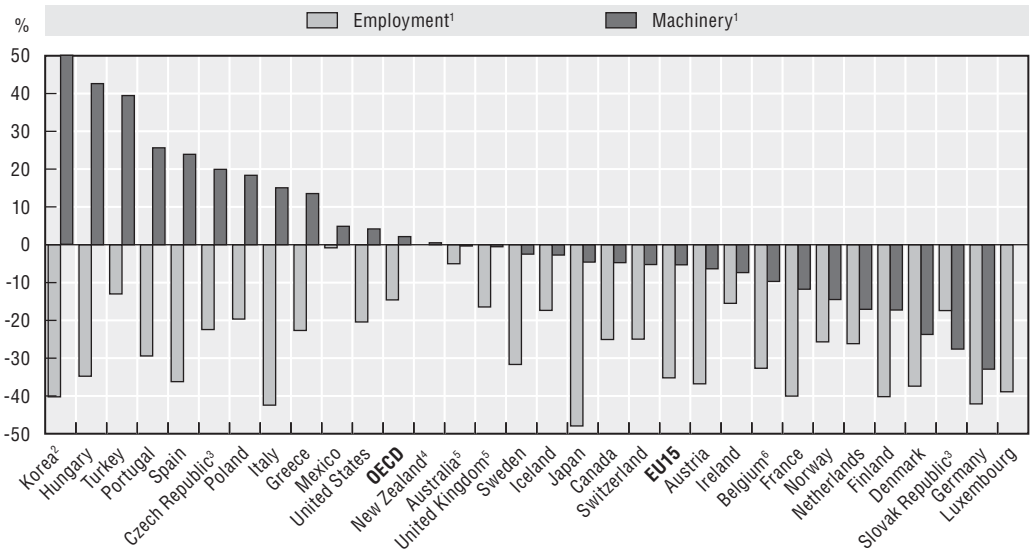
1. Data cover total on-farm energy consumption by primary agriculture (for irrigation, drying, horticulture, machinery and livestock housing), forestry, fishing and hunting.

Source: IEA (2006); and national data for Spain.

production (Section 1.1) but also improvements in energy efficiency, although the Eastern part of **Germany** was also affected by the transition to a market economy and a reduction in input subsidies (Figure 1.4.4).

Figure 1.4.4. **Agricultural employment and farm machinery use**

1990-92 to 2002-04



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1. Employment refers to economically active population in agriculture, and for some countries includes hunting, fishing and forestry. Farm machinery refers to tractors and combined harvester-threshers in use.
2. For Korea, change in agriculture machinery use is +181%.
3. Czech Republic and Slovak Republic: average 1990-92 = average 1993-95 percentage change for employment and machinery.
4. For New Zealand, change in agriculture machinery use is +0.5% and employment is 0%.
5. For Australia, change in agriculture machinery use is –0.3% and United Kingdom is –0.5%.
6. Including Luxembourg for machinery.

Source: FAOSTAT (2007).

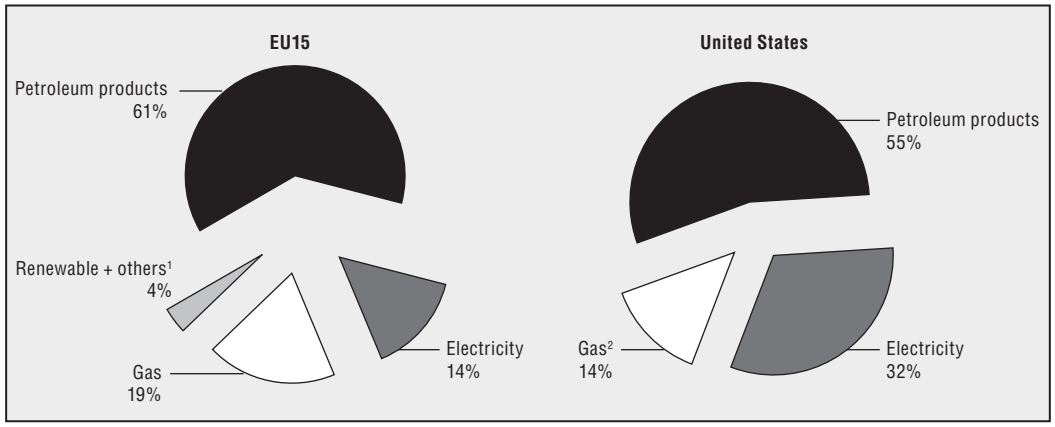
Petroleum products, mainly petrol and diesel, provide the main sources of on-farm energy consumption, accounting for over 50% in both the **EU15** and the **United States** (Figure 1.4.5), and over 80% in some countries (*e.g.* **Belgium**, **Ireland**, and **Portugal**). With the expansion in renewable energy production across many OECD countries, its share in on-farm energy consumption has risen, notably in **Austria, Denmark** and **Finland** (EEA, 2005). There has also been a trend in many countries toward replacing petrol by diesel, mainly due to lower prices for diesel relative to petrol, and an increasing share of electricity in on-farm energy consumption to power machinery, which partly reflects the gradual substitution of labour by these inputs (*e.g.* the **United States**, USDA, 1997).

There are many variables that explain trends in on-farm energy consumption, but three important elements include, first, the crude oil price; second, agricultural energy subsidies; and third, energy consumption efficiency. ***Trends in oil prices*** over the period 1990 to 2004, measured in real terms, showed a declining trend up to 1997-98, after which prices again begun to rise. To some extent this has been reflected in the trends in on-farm energy consumption across OECD countries, where on-farm energy consumption peaked around the mid-1990s, followed by a subsequent decline in consumption to 2004 (Figure 1.4.3).

Agricultural energy subsidies, mainly provided for fuel, are widespread across OECD countries, but also for power and heat in some cases (OECD, 2005; Chapter 3). Typically fuel subsidies are provided to farmers by reducing the standard rate of tax on petrol and/or diesel for machinery used only on-farm. In some cases support is also provided for other

Figure 1.4.5. **Composition of on-farm energy consumption in the EU15 and the United States**

2002



StatLink http://dx.doi.org/10.1787/287063358613

1. "Others" includes derived heat and solid fuel.
2. Natural and liquefied petroleum gas.

Source: EU: Eurostat, New Cronos (2007), US: Miranowski (2004).

energy sources, for example, energy to heat greenhouses in the **Netherlands** and electricity in **Mexico** (Chapter 3). The extent of the budget revenue foregone through these tax exemptions on fuel can be large, for example, nearly USD 1 billion in **France** and over USD 2.3 billion in the **United States**, annually (2004-06). In addition, energy subsidies to agriculture have in a number of countries lowered pump costs for extracting water, especially from groundwater sources, increasing the risk of depleting groundwater reserves beyond natural replenishment rates (Section 1.6.1).

Provision of fuel tax exemptions and other energy subsidies act as a disincentive to reducing on-farm energy consumption and using it more efficiently (OECD, 2005). Energy subsidies put pressure on the environment by increasing CO_2 emissions and other harmful air pollutants (UNEP/IEA, 2002).

Improvements in energy consumption efficiency by agriculture are apparent for many countries, *i.e.* the trend in on-farm energy consumption growing at a lower rate than growth in agricultural production. For example, energy consumption declined in **Austria**, **Denmark** and **France** despite an increase in agricultural production (Section 1.1). Calculation of an agricultural energy balance in **Switzerland** reveals that over the 1990s agricultural energy efficiency has been stable (Chapter 3). Similar research in **Canada** on agricultural input/output ratios showed that between 1989-95 and 1997-2001 energy efficiency declined by 12% due to the increase in diesel fuel (used as a substitute for petrol), and fertiliser use, with a corresponding decrease in high energy output crop production (Lefebvre *et al.*, 2005).

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1.5. SOIL

KEY TRENDS

Overall for the OECD there has been some improvement or stability in soil erosion, from both water and wind. An increase in the share of agricultural land within the tolerable erosion risk class has been accompanied by a reduction in areas at moderate to severe erosion risk.

Soil erosion from water for most OECD countries shows that the major share of agricultural land is within the tolerable erosion category and is not considered a concern. Almost a third of OECD member countries had more than 20% of agricultural land within the moderate to severe risk classes in the period 2000-02 (Greece, Hungary, Italy, Korea, Mexico, Portugal, Slovak Republic, Spain, Turkey). Over the average period 1990 to 2004 the share of land within these erosion risk classes, predominantly arable land, generally decreased or remained stable, although information on trends across OECD countries is limited.

Soil erosion from wind is also diminishing, although the number of countries for which wind erosion is a concern is smaller than for water erosion but cross country data are limited. Wind erosion is most prevalent in semi-arid areas or where soils exist in a very dry state for extended periods (Australia, Canada, Hungary, Iceland, Poland, United States).

Where ***risks of erosion remain,*** this is largely attributed to the: continued cultivation of fragile and marginal soils; overgrazing of pasture, especially in hilly areas; and poor uptake of soil conservation practices. In some regions erosion is aggravated by the increasing incidence and severity of droughts and/or heavy rainfall events, and in some countries land clearing (Mexico and Turkey). The reduction in agricultural land susceptible to moderate to severe risk of erosion is mainly linked to the growing uptake of soil conservation practices, such as the adoption of reduced or no tillage, and the conversion of agricultural land to forestry.

Estimates show that the ***costs of soil erosion damage can be considerable.*** On-farm costs correspond essentially to the agricultural production foregone as a result of soil degradation lowering crop productivity. Off-farm costs, resulting from off-farm sediment flows, include: extra expense to treat drinking water; costs of dredging rivers, lakes and reservoirs; damage to roads and buildings; and harmful effects on aquatic ecosystems, including recreational and commercial fishing.

Indicator definitions:

- Area of agricultural land affected by **water erosion** in terms of different classes of erosion, *i.e.* tolerable, low, moderate, high and severe.
- Area of agricultural land affected by **wind erosion** in terms of different classes of erosion, *i.e.* tolerable, low, moderate, high and severe.

Concepts and interpretation

Soil erosion, principally by water and to a lesser extent wind, is considered to be the highest priority soil quality issue for some OECD countries. Other soil degradation processes, including compaction, acidification, toxic contamination and salinisation largely relate to specific regions in some countries and therefore it is not possible to provide an overview of OECD trends (Chapter 3).

Soil plays a key role in maintaining a balanced ecosystem and in producing quality agricultural products (OECD, 2003). There can be a significant time delay between recognising soil degradation and developing conservation strategies, in order to maintain soil health and crop productivity. The intensity of rainfall, degree of protective crop cover, slope and soil type are the controlling factors of water erosion. The process of wind erosion is also controlled by climate (soil moisture conditions), crop cover and soil type and involves detaching and transporting soil particles (mainly silt and fine sand) over varying distances. Loss of topsoil by erosion also contributes to the loss of nutrients. Soil tillage practices can also contribute to erosion by moving soil on hilly landscapes, *i.e.* removing soil from the slopes' top to the bottom (Lobb *et al.*, 2003; Torri, 2003).

Indicators for soil erosion from water are generated by models, most often variants of the Universal Soil Loss Equation (USLE). Although these models take account of soil type, topography, climate and crop cover, they are using generalized inputs that provide estimates of soil erosion risk rather than actual field measurement values. Some OECD countries have well established soil monitoring systems (*e.g.* the **United States**) that provide field observations to directly validate national risk estimates. Other OECD countries are in the early stages of implementing similar field measurement systems (*e.g.* **Australia**, **Canada** and **New Zealand**); while others, including several **European Union** countries, are in the process of designing such monitoring systems (EEA, 2005; Montanarella *et al.*, 2003). It is important to stress that these trends only concern on-farm soil erosion.

While the USLE is commonly used by most OECD countries, the limits of risk of soil erosion classes reported from tolerable to severe vary between some countries (see OECD website database), but, a standardised scale has been used by OECD to present these data. Agricultural soils can "tolerate" a certain amount of erosion without adversely impacting on long-term productivity because new soil is constantly being formed to replace losses. The tolerable limit varies between different soil depths, types and agro-climatic conditions, but typically ranges from 1 tonne/hectare/year on shallow sandy soils to 6 tonnes/hectare/year on deeper well-developed soils. OECD's scale of soil erosion risk categories ranges from tolerable erosion (< 6 tonnes/hectare/year) through low, moderate, high and finally to severe erosion (> 33 tonnes/hectare/year). However, not all countries use these class limits as some consider tolerable erosion as less than 4 tonnes/hectare/year (*e.g.* the **Netherlands**, and the **Czech** and **Slovak Republics**).

Changes in agricultural land cover and use (Sections 1.1 and 1.8), farm production intensity (Section 1.1), and management practices and systems (Section 1.9) are the key ***driving forces*** covered by the soil erosion indicators which describe the ***state*** (or risk) of on-farm erosion. These indicators are useful tools for policy makers as they provide an assessment of the long-term environmental sustainability of management practices and the effectiveness of soil conservation measures. They can also be related to a range of soil quality issues including the loss of soil organic matter and soil biodiversity (Chapter 2). Changes in soil management practices (Section 1.9) are a ***response*** to improving soil quality and soil erosion risks.

Recent trends

The OECD trend shows some improvement or stability in most cases for soil erosion, from both water and wind. This is highlighted by an increase in the share of agricultural land within the tolerable erosion risk class relative to a reduction in areas at moderate to severe erosion risk, notably in those countries where soil erosion is a significant environmental issue, such as in **Canada** and the **United States**. The overall reduction in agricultural land susceptible to a high risk of erosion is mainly linked to both the increased uptake of soil conservation practices, such as the adoption of reduced or no tillage (Section 1.9), and also the conversion of agricultural land to forestry (Section 1.8). Where risks of erosion still remain a concern this is largely attributed to the: continued cultivation of fragile and marginal soils; overgrazing of pasture, especially in hilly/mountainous areas; and the poor uptake of soil conservation practices. Also, in some regions soil erosion is being aggravated by the increasing incidence and severity of droughts and/or heavy rainfall events (*e.g.* **Australia, Italy** and **Spain**), and in some countries clearing of native vegetation and forests (*e.g.* **Mexico** and **Turkey**).

Research shows that there are several costs associated with soil erosion damage, which can be considerable (*e.g.* see **Australia**, the **United Kingdom** and the **United States**, Chapter 3). On-farm costs refer mostly to the agricultural production foregone as a result of soil degradation lowering crop productivity. Off-farm costs, resulting from off-farm sediment flows, include: extra expense to treat drinking water; costs of dredging rivers, lakes and reservoirs; damage to roads and buildings; and harmful effects on aquatic ecosystems, adversely affecting recreational commercial fishing.

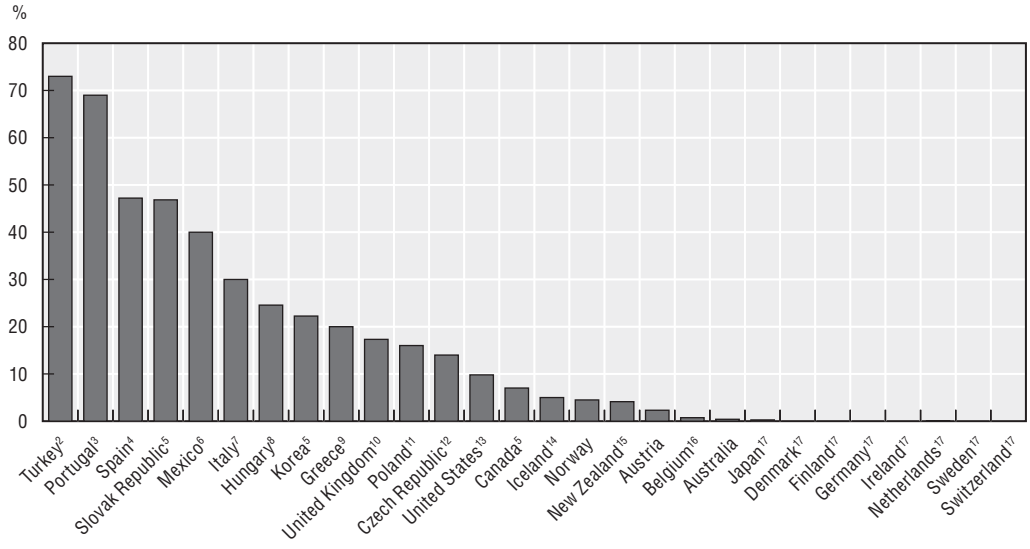
Soil erosion from water for most OECD countries shows that the major share of agricultural land is within the tolerable water erosion category and thus erosion is not considered a concern (Figure 1.5.1). Almost a third of OECD countries have more than 20% of agricultural land within the moderate to severe risk classes for the average period of 2000-02 (Figure 1.5.1). Over the period 1990 to 2004 the share of land within the moderate to severe erosion risk classes generally decreased or remained stable, although information on trends is limited (Figure 1.5.2, Chapter 3).

Soil erosion from wind depicts a similar trend, although the number of countries for which this is a serious problem is much smaller than for water erosion. Trends in the OECD agricultural land area within the modest to severe wind erosion risk categories are mainly stable or downwards over the 1990s, but cross country data are limited. Wind erosion is most prevalent in arid and semi-arid areas or where soils can exist in a very dry state for extended periods.

Soil erosion can originate from a number of economic activities (*e.g.* forestry, construction, off-road vehicle use) and natural events (*e.g.* fire, flooding and droughts). In most cases, however, the major share of soil erosion is accounted for by agricultural activities. In general, cultivated arable and permanent crops (*e.g.* orchards) are more susceptible to higher levels of soil erosion compared to pasture areas. This is because land under pasture is usually covered with vegetative growth all year. In **Spain** and the **United States**, for example, of agricultural land in the moderate to severe water erosion risk classes, arable and permanent cropland accounted for 75% and nearly 90%, respectively, over 1995-99 (OECD website database). However, where pasture is located on fragile soils with steep topography and subject to intensive grazing, problems of soil erosion can be more acute than on cultivated land, for example, in **Italy**, **New Zealand** and the **United Kingdom**.

Figure 1.5.1. **Agricultural land area classified as having moderate to severe water erosion risk**[1]

Average 2000-02



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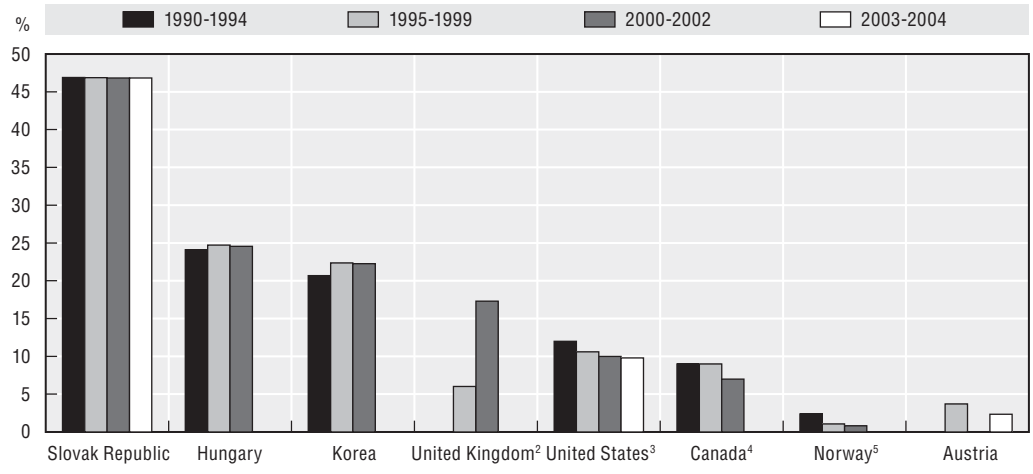
1. Risk of water erosion greater than 11 t/ha/y of soil loss, unless otherwise indicated.
2. Share of agricultural land of risk to elevated erosion rates, but t/ha/y not specified.
3. Covers all land including agricultural land, and covers high risks, but not defined source OECD (2001), Environmental Performance Review of Portugal.
4. Average 1987-2000 of actual area affected by erosion above 12t/ha/year.
5. Data for 2002-04.
6. *Source:* Chapter 3, Mexico country section.
7. Soil erosion risk greater than 10 t/ha/y, for all land, including agricultural land, 1999.
8. Data for 2000-02.
9. Covers all land, including agricultural land. *Source:* Montanarella *et al.* (2003).
10. For England and Wales. Data reported in terms of erosion events (not t/ha/y) occurring annually or every 3 years for moderate to severe erosion categories.
11. Data for 2005.
12. Data for 1999, severe risk classified as greater than 7.5 t/ha/y.
13. Water erosion on cropland, pasture land and Conservation Reserve Program land, above 11 t/ha/year for 2003.
14. Late 1990s, permanent grassland only, comprising 95% of the total agricultural land area. Moderate to severe erosion not classified by soil loss but by farmland.
15. No specific years provided.
16. Data for Flanders (1998) and Wallonia (1995-99).
17. These countries report that the risk of moderate to severe water erosion was between zero or less than 0.5%, of the total agricultural land area over the period 2000-02.

Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; and OECD Agri-environmental Indicators Questionnaire, unpublished; and national sources.

About 17% of the total land area in ***Europe*** is affected, to some degree, by soil erosion, but only 4% is affected by severe erosion. Soil erosion in Europe is mainly due to water (about 92% of the total) and less to wind, while it is becoming apparent that there is a trend towards shifting the balance from severe to tolerable erosion risk classes (EEA, 2005; Montanarella *et al.*, 2003). In 2002 the European Commission launched "*Towards a thematic strategy for soil protection*" aiming to consider, amongst other issues, soil protection measures as a way of addressing problems of soil erosion (EUROPA, 2003).

The Mediterranean region of Europe is particularly at high risk to soil erosion from water, mainly **Italy, Portugal, Spain, Turkey**, and to a lesser extent **Greece** (Figure 1.5.1). Frequent dry periods followed by outbreaks of rain increases the risk of severe soil erosion, particularly in areas of the Mediterranean with steep topography, fragile soils and little

Figure 1.5.2. **Trends in agricultural land area classified as having moderate to severe water erosion risk**[1]



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Note: Finland, Germany, Ireland, Japan, Netherlands, Sweden and Switzerland report that the risk of moderate to severe water erosion over the period 1990-2004 (see Figure 1.5.1) was between zero to less than 0.5% of the total agricultural land area.

1. Risk of water erosion greater than 11 t/ha/y of soil loss, unless otherwise indicated.
2. For England and Wales. Data reported in terms of erosion events (not t/ha/y) occurring annually or every 3 years for moderate to severe erosion categories.
3. Water erosion on cropland, pasture land and Conservation Reserve Programme land for 1992, 1997, 2001 and 2003 greater than 11 t/ha/year.
4. Values for 1991, 1996 and 2001 respectively for cropland and summer fallow.
5. Only for severe erosion category classified as greater than 8 t/ha/y.

Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; and OECD Agri-environmental Indicators Questionnaire, unpublished.

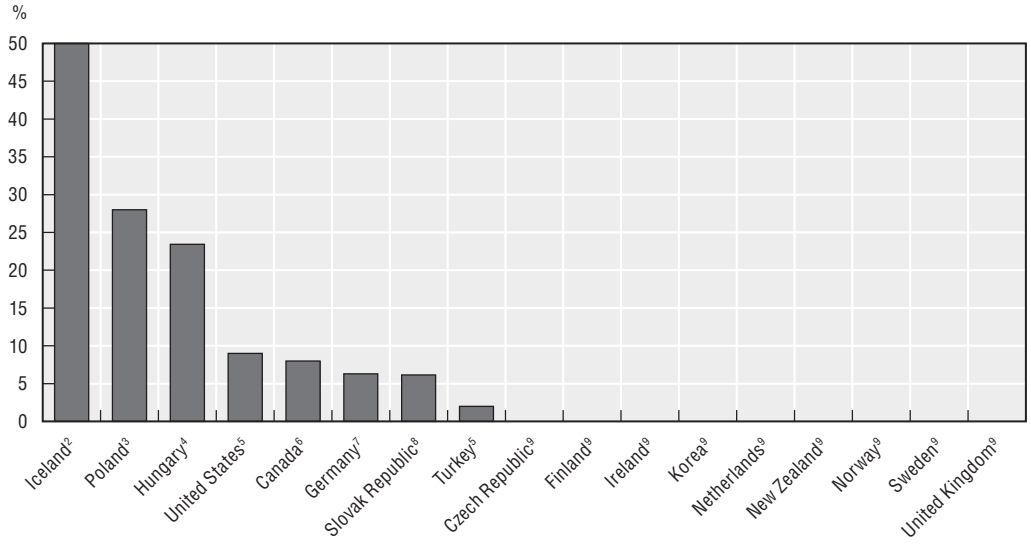
vegetation cover. While other parts of Europe are less prone to severe cases of erosion, there is concern over erosion risks from water and wind in central Europe (the **Czech** and **Slovak Republics, Hungary, Poland**) and wind erosion in **Iceland** (Figures 1.5.1-1.5.3). Evidence for these countries suggests, however, that soil erosion risks are being exacerbated by the relatively poor uptake of soil management practices and limited area of land under protective cover over the year (Section 1.9 and Chapter 3).

In North America, **Canada** and the **United States** have experienced a decrease in the amount of land classified as belonging to the moderate to severe water erosion class (Figure 1.5.2). In **Mexico**, however, soil erosion is a key environmental concern, with around 40% of all land in the moderate to severe risk erosion classes (Figure 1.5.2). Mexican agriculture is estimated to account for nearly 80% of soil degradation from overgrazing, tillage burning, excess tilling and poor uptake of soil conservation practices (Chapter 3).

In the **United States**, concern over soil erosion has been influential in reducing the risk of erosion to agricultural soils over many decades. By 2003, areas under moderate to severe risk were under 10% of total agricultural land compared to 12% in 1992 (Figures 1.5.1-1.5.3). Soil conservation policy targets for *Highly Erodible Land* (HEL) requires farmers to implement conservation plans to protect the soil or risk losing Federal farm programme benefits. Payments for no tillage practices are generally higher than those for reduced tillage practices. Erosion processes vary between regions, for example, semi-arid western States suffer from wind erosion, while eastern States are more prone to water erosion (Claassen *et al.*, 2004; and Chapter 3).

Figure 1.5.3. **Agricultural land area classified as having moderate to severe wind erosion risk**[1]

Average 2000-04



StatLink http://dx.doi.org/10.1787/287144865677

1. Risk of wind erosion greater than 11 t/ha/y of soil loss, unless otherwise indicated.
2. Late 1990s, permanent grassland only, comprising 95% of the total severe erosion not classified by soil loss but by farmland.
3. Data for 2005.
4. Data show agricultural land covered by all wind erosion risk categories from tolerable to severe erosion risk for 1995-99.
5. Share of agricultural land of risk to elevated erosion rates, but t/ha/y not specified.
6. Data for period 2000-02, for cropland and summer fallow only.
7. Data for 1995-99.
8. Data for 2003-04.
9. These countries report that the risk of moderate to severe wind erosion was very limited between zero and less than 0.5% of the total agricultural land area.

Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France and OECD Agri-environmental Indicators Questionnaire, unpublished; and national sources.

Soil erosion from water in **Canada** has seen some reduction over the 1990s, declining to about 7% of cropland and summer fallow area with a moderate to severe risk of water erosion by 2000-02 compared to 9% in 1990-94 (Figure 1.5.2). This has been attributed to better management of soils and greater farmer awareness of minimising soil erosion. Research on wind erosion indicates that about 8% of the cropland and summer fallow area is at moderate to severe risk (Figure 1.5.3), which is a decrease from 11% in the early 1990s. Changes in management practices, such as an increase in vegetative protective cover (Section 1.9) are acknowledged as being the reason of this decrease (Lefebvre *et al.*, 2005).

For **Australia**, evidence from the late 1990s suggests that there may be some reduction in soil erosion rates (Hamblin, 2001). But, in 1999, some 11% of farmers experienced significant soil degradation caused by water erosion and 2% encountered severe wind erosion, while on average, 90% of Australia's soil erosion from agriculture comes from 20% of the agricultural land area (National Land and Water Resources Audit, 2002). Farming practices have exacerbated the extent and rate of soil degradation with up to a third of the total area of rangeland showing acute symptoms of soil degradation, and 50-65% of crop land at risk in any one season from wind erosion. Soil erosion studies in Australia have revealed high costs, estimated annually at AUD 80 million (USD 45 million) in infrastructure repairs

and AUD 450 million (USD 250 million) in water quality contamination as the result of soil erosion (Chapter 3). However, problems of soil degradation through salinity, acidity and sodicity are a much greater problem in Australia than soil erosion (Chapter 3).

New Zealand experiences high rates of natural erosion due to extremes of climate and topography, but soil quality has come under pressure from overgrazing. About two-thirds of pastoral land is sustained with improved land management practices, estimated to cost USD 12 million annually, which has included reforestation in some areas (Chapter 3). However, only about 4% of agricultural land is estimated to be in the moderate to severe risk classes for soil erosion from water (Figure 1.5.1).

In **Korea** the main process of soil erosion on agricultural land is water erosion, as over half the annual rainfall is concentrated in the summer months, with over 20% of farm land classified as having moderate to severe risks (Figure 1.5.1). During the period 1990 to 2002 the land classified as having moderate to severe water erosion risk decreased by around 15 000 hectares, but its share in the total agricultural land area rose, as the decrease in the area of agricultural land was greater by about 220 000 hectares over this period (Figure 1.5.2). Annual soil loss from dry crop land is 32 tons/hectare/year (26 million tons per year), contrary to paddy rice fields experiencing only 0.02 ton/hectare/year (0.02 million tons per year) (Hur *et al*., 2003). This is mainly because paddy fields may act as a buffer and prevent raindrops and water flow from directly affecting the soil's surface, and is also important in **Japan** where 55% of agricultural land is under paddy rice production (Chapter 3).

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1.6. WATER

KEY TRENDS

Overall OECD agricultural water use rose by 2% compared to no change for all water users over the period 1990-92 to 2001-03, but for over a third of OECD countries water use decreased. In total OECD agriculture accounted for 44% of total water use in 2001-03. Much of the OECD growth in agricultural water use has occurred in Australia, Greece, Portugal and Turkey

In aggregate the ***OECD area irrigated rose by 8%*** compared to a reduction of –3% in the total agricultural area between 1990-92 and 2001-03. Where irrigated agriculture accounts for a major share in the total value of agricultural production and exports, agricultural production projections over the next 10 years suggest that agricultural water demand could increase together with growing competition for water from other users. For some countries where irrigation plays a key role in the agricultural sector and farming is also a major water user in the economy, the growth in agricultural water use over the past decade has been above that compared to other water users (Australia, Greece, Portugal, Spain and Turkey).

Over-exploitation of some water resources by agriculture has damaged aquatic ecosystems, including harming recreational and commercial fishing activities. Monitoring minimum water flow rates in rivers is now a part of environmental planning in many countries. The growing incidence and severity of droughts over the past decade in some regions is an increasing pressure on irrigated farming in drier and semi-arid areas.

Although data are limited, farming is drawing an increasing share of its supplies from aquifers, and ***agriculture's share in total groundwater utilisation was above 30% in a third of OECD member countries*** in 2002. Use of groundwater by irrigators is substantially above recharge rates in some regions of Australia, Greece, Italy, Mexico and the United States, which is undermining the economic viability of farming in certain regions. Farming is now the major and growing source of groundwater pollution across many countries. This is of particular concern where groundwater provides a major share of drinking water supplies for both human and the farming sector (*e.g.* Greece, Mexico, Portugal, the United States).

Government support for irrigation is widespread across OECD countries, covering the totality or part of the irrigation infrastructure construction costs and those associated with water supply pricing. Energy subsidies to agriculture have in a number of countries significantly lowered costs for extracting water, especially from groundwater sources. But some countries use full cost recovery for water provision to farmers (Austria, Netherlands) or are beginning to implement water policy reforms (Australia, Mexico, Spain).

The low uptake of water efficient irrigation technologies, such as drip emitters, and the poor maintenance of irrigation infrastructure (*e.g.* canals) has led to inefficiencies in water use and water losses through leakages leading to an increase in water application rates per hectare irrigated. Even so, overall the OECD average water application rate per hectare irrigated has declined by –9% (1990-92 to 2001-03), notably decreasing in Australia, but also to a lesser extent in Mexico, Spain and the United States, but increasing for others, for example in Greece, Portugal and Turkey.

KEY TRENDS *(cont.)*

The overall pressure of agriculture on water quality in rivers, lakes, groundwater and coastal waters eased over the period 1990 to mid-2000s due to the decline in nutrient surpluses and pesticide use for most OECD countries. Despite this improvement, absolute levels of nutrient and pesticide pollution remain significant in many countries and regions. Moreover, the share of farming in nutrient water pollution has risen as industrial and urban sources have decreased absolute levels of pollution more rapidly than for agriculture. However, only around a third of OECD countries monitor agricultural nutrient water pollution and even fewer monitor pesticide pollution.

Nearly a half of OECD member countries record that nutrient and pesticide concentrations in surface water and groundwater monitoring sites in agricultural areas exceed national drinking water recommended limits. Of concern is agricultural pollution of groundwater drawn from shallow wells and deep aquifers, especially as natural recovery rates from pollution can take many decades, in particular, for deep aquifers. But the share of monitoring sites in rivers, lakes and marine waters that exceed maximum recommended national limits for environmental and recreational uses is much higher with agriculture a major cause of this pollution in many cases. This is evident in the widespread eutrophication of surface water across OECD countries, and the damage to aquatic organisms from pesticides. Estuarine and coastal agricultural nutrient pollution is also an issue in some regions causing algal blooms that damage marine life, including commercial fisheries, in the coastal waters of Australia, Japan, Korea, United States, and Europe.

The economic costs of treating water to remove nutrients and pesticides to ensure water supplies meet drinking water standards are significant in some OECD countries. In the United Kingdom, for example, the cost of water pollution from agriculture was estimated to cost around EUR 345 million annually in 2003/04. Eutrophication of marine waters also imposes high economic costs on commercial fisheries for some countries (*e.g.* Korea, United States).

1.6.1. Water use

Indicator definitions:

- Agricultural water use in total national water utilisation.
- Agriculture's use of groundwater in total national groundwater utilisation.
- Area of irrigated land in total agricultural land area.

Concepts and interpretation

In many OECD countries there is growing competition for water resources between industry, household consumers, agriculture and the environment (*i.e.* aquatic ecosystems). The demand for water is also affecting aquatic ecosystems particularly where water extraction is in excess of minimum environmental needs for rivers, lakes and wetland habitats. However, some OECD countries possess abundant water resources and, as a result, do not consider water availability to be a significant environmental issue in terms of resource protection. There are also important social issues concerning water, such as access for the poor in rural areas, while in some societies water has a significant cultural value, for example, for the indigenous peoples of **Australia** and **New Zealand**, and in **Korea** and **Japan** (OECD, 2004).

Water use indicators provide information on the trends in agricultural water use, and the importance of the sector in total national water use (OECD, 2004). The indicators show that overexploitation of water resources, especially by agriculture, which is the major user in many cases, is becoming an increasing problem for a large number of regions across OECD. This is of concern for allocating water resources between different consumers in the context of depleting groundwater resources. Depletion of groundwater resources can also endanger aquatic ecosystems (Chapter 2) and in some cases cause land subsidence leading to damage to buildings (EEA, 2005).

A key driving force that affects agricultural water use is irrigated agriculture. Irrigation water prices also impact on water use, especially where water pricing for farmers do not cover delivery costs while those for other major water users do (*i.e.* industry, urban) (Chapter 2). Some OECD countries are promoting improved water management practices and technologies for more efficient uses of resources (Section 1.9) and to prevent over-extraction of water from surface water and aquifers where water levels may already be low. Water use can also be limited by reducing losses in water transport systems and varying the type of crop grown.

Calculations of water balances are complex and not all OECD countries use the same data collection methods, which is a limitation in using these indicators. A further limitation is that water use balances are not usually calculated annually, but derived from 5 or even 10 year surveys. Moreover, the extent of groundwater reserves and their rate of depletion are also not easily measured, and cross country time series data are lacking. An additional complication is that under some systems, agriculture has the potential to recharge groundwater (Chapter 2).

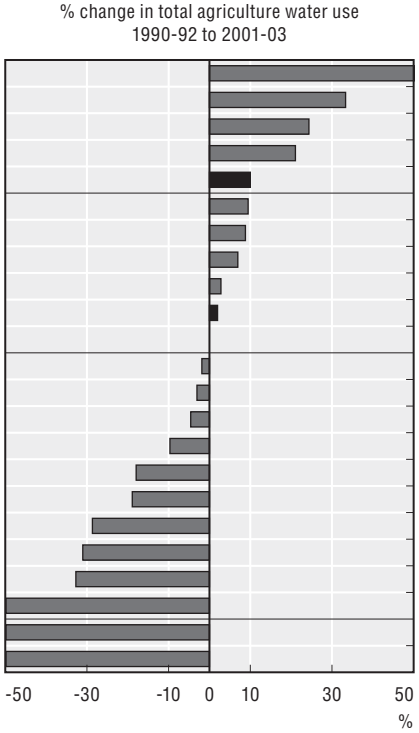
The term "agricultural water use" used in the text and figures in this section refers to "water abstractions" for irrigation and other agricultural uses (such as for livestock) from rivers, lakes, and groundwater, and "return flows" from irrigation but excludes precipitation directly onto agricultural land. "Water use" (*i.e.* water actually consumed by agricultural production activities), or in the technical literature "water withdrawals", is different from "water consumption" which only covers "water abstractions" and does not include "return flows" that occur in irrigated systems.

As environmental ***driving forces*** the agricultural water use and irrigated area indicators linked to the ***state*** of (changes in) groundwater reserves and competition over water resources with other major users. ***Responses*** to these changes in the sustainability of water use are revealed through indicators of water prices (Chapter 2) and uptake of more efficient irrigation management technologies and practices (Section 1.9).

Recent trends

Overall OECD agricultural water use rose by 2% compared to no change for all water users over the period 1990-92 to 2001-03, but for over a third of OECD countries water use decreased (Figure 1.6.1). Much of the growth in OECD agricultural water use has occurred in **Australia**, **Greece**, **Portugal** and **Turkey**. Moreover, for these countries the growth in agricultural water use has been higher than for other national water users, while agriculture's share in total water use is above 75% for these four countries (Figure 1.6.3). The growth in agricultural water use is also significant for other countries as farming accounts for 44% of total OECD water use (Figure 1.6.3). Even so, there are no cases of an overall national physical shortage of water, as the share of total water use in total availability of annual freshwater resources is low

Figure 1.6.1. **Agricultural water use**[1]



	Total agriculture water use[1]		Change in total agriculture water use	Change in total water use[2]	Share of agriculture in total water use[2]
	1990-92	2001-03	1990-92 to 2001-03	1990-92 to 2001-03	2001-03
	Million m^3		%		
Turkey[3]	18 812	31 000	65	28	78
Greece[4]	5 694	7 600	33	24	87
Australia[5]	13 384	16 660	24	9	77
Portugal[6]	5 100	6 178	21	–2	75
EU15[7]	**38 961**	**42 877**	**10**	**–9**	**30**
United Kingdom[8]	1 347	1 476	10	16	10
Spain[9]	19 667	21 407	9	4	60
Korea[10]	14 700	15 800	7	33	48
Canada[11]	3 991	4 104	3	–6	10
OECD[12]	**409 088**	**417 190**	**2**	**0**	**44**
Iceland[13]	70	70	0	–1	43
United States[14]	195 200	191 555	–2	2	40
Japan[15]	58 630	56 840	–3	–3	66
France	4 901	4 676	–5	–14	14
Mexico	62 500	56 451	–10	0	77
Austria[16]	100	82	–18	–50	5
Sweden[17]	169	137	–19	–10	5
Germany[18]	1 600	1 140	–29	–21	3
Poland	1 527	1 052	–31	–18	9
Hungary	1 032	694	–33	–21	13
Denmark[19]	383	181	–53	–38	27
Slovak Republic[20]	188	72	–62	–41	7
Czech Republic[21]	93	15	–84	–45	1
Italy[22]	. .	20 140	. .	0	36

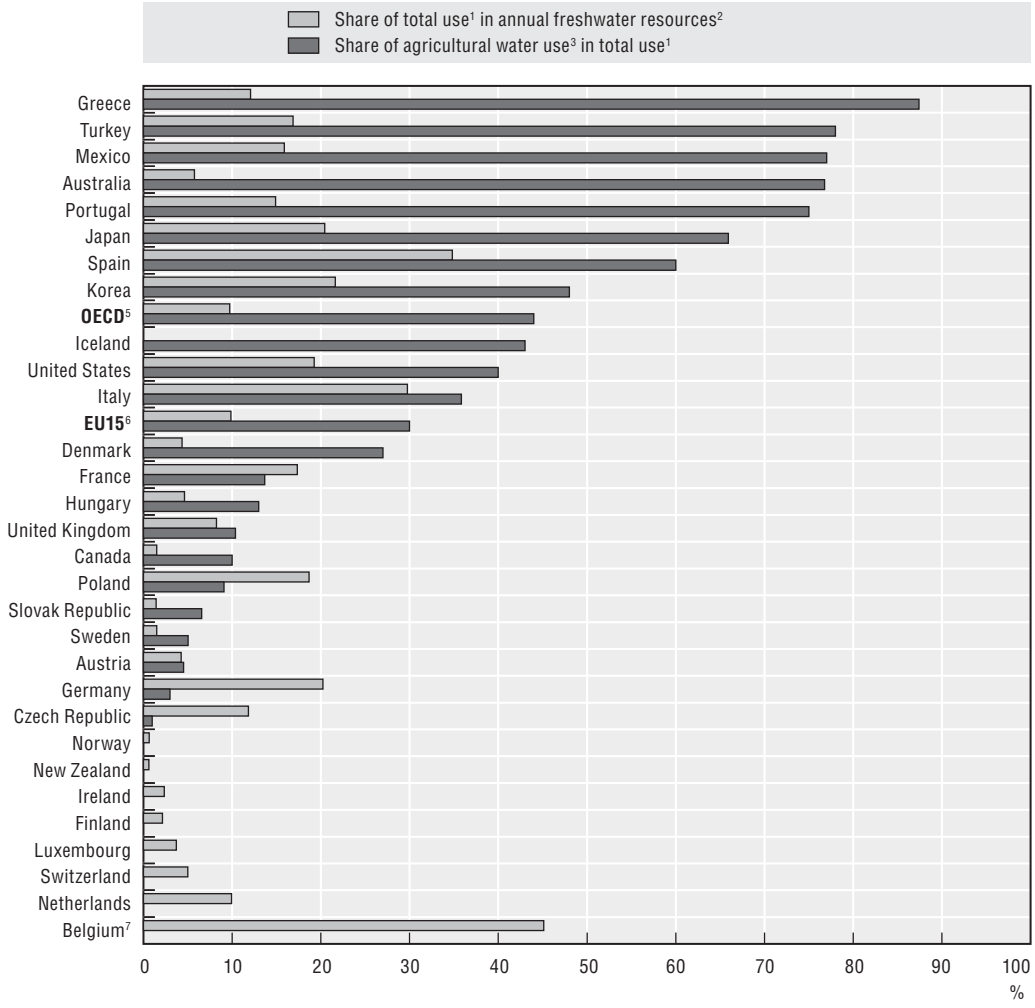
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1. Agricultural water use is defined as water for irrigation and other agricultural uses such as for livestock operations. It includes water abstracted from surface and groundwater, and return flows from irrigation but excludes precipitation directly onto agricultural land.
2. Total water use is the total water abstractions for public water supply + irrigation + manufacturing industry except cooling + electrical cooling.
3. Data for the period 2001-03 refer to the year 2001. Data for irrigation are used because data for agricultural water use are not available. For Turkey, change in total agricultural water use is +65%.
4. Data for the period 1990-92 and 2001-03 refer to the year 1985 and 2001. Share of agriculture in total water use is for 1997.
5. Average 1990-92 = average 1993-95, average 2001-03 = (2000).
6. Data for the periods 1990-92 and 2001-03 refer to the years 1991 and 2001. Data for irrigation (year 1991) are used because data for agricultural water use are not available.
7. EU15 excludes: Belgium, Finland, Ireland, Italy, Luxembourg, Netherlands.
8. England and Wales only.
9. *Source:* "Libro Blanco del Agua" and "Plan Nacional de Regadios Horizonte 2008".
10. Data for the periods 1990-92 and 2001-03 refer to the years 1990 and 2002.
11. Data for the periods 1990-92 and 2001-03 refer to the years 1991 and 1996.
12. OECD excludes: Belgium, Finland, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Norway, Switzerland.
13. Data for the period 1990-92 refer to the year 1992. Data include water use for fish farming.
14. Data for the periods 1990-92 and 2001-03 refer to the years 1990 and 2000.
15. Data for the periods 1990-92 and 2001-03 refer to the years 1990 and 2001.
16. Data for the period 2001-03 refer to the year 2003. *Sources: Austrian Federal Ministry for Agriculture, Forestry, Environment and Water Management, Facts and Figures 2006* and *Austrian Water, Facts and Figures,* see Chapter 3.
17. Data include water use for fish farming.
18. Data for the period 2001-03 refer to the year 2001. Data for irrigation are used because data for agricultural water use are not available.
19. Until 1999 abstraction for irrigation included abstraction for freshwater fish farms, accounting for approximately 40 million m^3/year.
20. For the Slovak Republic, the change in total agricultural water use is –62%.
21. For the Czech Republic, the change in total agricultural water use is –84%.
22. For 1990-92, data for agricultural water use are not available. Data for the period 2001-03 refer to the year 1999.

Source: OECD Environmental Data Compendium 2004, Paris, France; OECD Secretariat estimates; national data for Australia, Austria, Denmark, Hungary, Korea and Spain.

Figure 1.6.2. **Share of national water use in annual freshwater resources and share of agricultural water use in national use**

Average 2001-03[4]



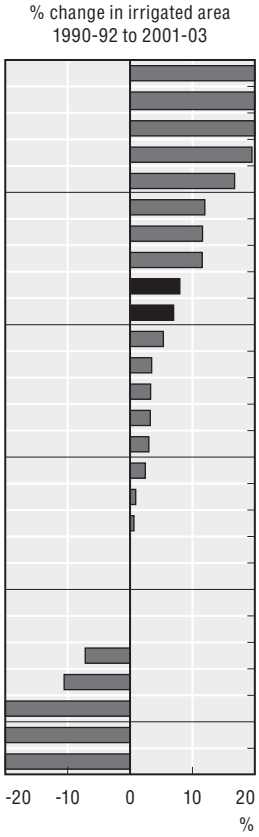
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1. Total use (abstractions) of water by all users, including public water supply, agriculture, industry, and for power station cooling.
2. Annual freshwater resources include: Mean annual precipitation + transborder water flows – mean annual evapotranspiration (over-exploitation of groundwater resources was not included in the calculation).
3. Agricultural water use includes water abstracted from surface and groundwater, and return flows (withdrawals) from irrigation for some countries, but excludes precipitation directly onto agricultural land.
4. The average of 2001-03 equals: 1996: Canada. 1997: Greece. 1999: Italy. 2000: Australia and Korea. 2001: Japan. 2002: Czech Republic, Denmark, France, Portugal and Spain (*sources:* "Libro Blanco del Agua" and "Plan Nacional de Regadios Horizonte 2008"). 2003: Austria.
5. OECD excludes: Belgium, Finland, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Norway, Switzerland.
6. EU15 excludes Belgium, Finland, Ireland, Italy, Luxembourg and Netherlands.
7. Only Flanders.

Source: OECD Environmental Data Compendium 2004, Paris, France.

(Figure 1.6.2). But the supply and demand for water resources varies greatly across regions in most countries, and as a result competition for water between agriculture, other users (*e.g.* industrial, urban) and for environmental purposes, especially in drier regions, is becoming a growing concern in many countries.

Figure 1.6.3. **Irrigated area, irrigation water use and irrigation water application rates**



	Irrigated area[1]		Change in irrigated area		Change in total agricultural area	Share of irrigated area in total agricultural area	Share of irrigation water use in total agricultural water use	Irrigation water application rates		
	'000 hectares		'000 hectares	%	%			Megalitres per hectare of irrigated land		
	1990-92	2001-03	1990-92 to 2001-03	1990-92 to 2001-03	1990-92 to 2001-03[2]	2001-03	2001-03	1990-92	2001-03	% change
New Zealand[2, 3]	250	475	225	90	–3	4	. .	. .	. .	. .
Belgium[4]	24	40	16	67	2	3	22	0.1	0.2	104
France[5]	2 150	2 632	482	22	–2	9	. .	. .	. .	. .
Canada[2, 6]	900	1 076	176	20	–3	2	94	3.5	3.6	1
Australia[2]	2 057	2 402	345	17	–6	1	90	8.7	4.3	–50
United States[2, 7]	19 994	22 384	2 390	12	–4	5	99	9.4	8.4	–10
Sweden[2, 8]	48	54	6	12	–6	2	70	2.1	1.7	–19
Spain	3 200	3 442	242	8	–2	9	100	7.4	7.0	–5
OECD[9]	**48 979**	**52 830**	**3 850**	**8**	**–3**	**4**	**. .**	**9.2**	**8.4**	**–9**
EU15[10]	**11 778**	**12 618**	**840**	**7**	**–3**	**9**	**. .**	**5.6**	**6.1**	**8**
Turkey	3 329	3 506	177	5	1	9	. .	5.7	8.8	56
Greece	1 383	1 431	48	3	0	17	100	5.5	5.9	7
Denmark	433	448	14	3	–5	17	93	0.7	0.4	–48
United Kingdom	165	170	5	3	–10	1	9	1.0	0.6	–43
Portugal	631	650	19	3	–4	17	100	8.1	9.5	18
Mexico	6 170	6 320	150	2	1	6	97	9.9	8.7	–12
Netherlands	560	565	5	1	–3	29	80	0.3	0.1	–59
Germany	482	485	3	1	–1	3	. .	3.3	0.3	–91
Austria	4	4	0	0	–3	0	5	12.5	2.5	–80
Italy[11]	2 698	2 698	0	0	–1	17	100	. .	7.7	. .
Poland	100	100	0	0	–8	0.6	8	3.7	0.9	–77
Switzerland	25	25	0	0	–3	2	. .	. .	. .	. .
Japan	2 846	2 641	–205	–7	–8	55	99	20.4	21.3	5
Korea	984	880	–104	–11	–12	46	. .	14.3	. .	. .
Hungary[12]	205	126	–79	–39	–8	2	21	2.1	1.2	–44
Slovak Republic[2, 13]	299	153	–146	–49	0	6	73	0.5	0.4	–31
Czech Republic[2, 14]	43	20	–23	–54	0	1	60	0.7	0.6	–21

StatLink http://dx.doi.org/10.1787/287167551181

. .: Not available.

1. Covers area irrigated and not irrigable area (*i.e.* area with irrigation infrastructure but not necessarily irrigated.) To be consistent, the years used for the average calculations are the same for irrigation water use and total agricultural water use, irrigated area and total agricultural area.
2. For some countries, data in brackets below are used to replace the average due to missing data: Australia: 1990-92 (1996), 2001-03 (2003). For total agriculture water use data are available in 2000. Canada: 1990-92 (1988), 2001-03 (2003). Czech Republic: 1990-92 (1994), 2001-03 (2003). New Zealand: 1990-92 (1985), 2001-03 (2003). Slovak Republic: 1990-92 (1994), 2001-03 (2003). Sweden: 1990-92 (1988), 2001-03 (2003). United States: 1990-92 (1992), 2001-03 (2002), and for irrigation water application rates data are available for 1990 and 2000.
3. New Zealand, share of irrigation water in total agriculture water use, for 2002, see Chapter 3. Change in irrigated area is +90%.
4. For Belgium, the change in irrigated area is +67%.
5. For France, the change in irrigated area is +22%.
6. For Canada, the source is the OECD questionnaire.
7. For the United States, the source is the Census of Agriculture.
8. For Sweden, the source is the questionnaire.
9. OECD excludes: Finland, Iceland, Ireland, Luxembourg, Norway, Switzerland.
10. EU15 excludes: Finland, Ireland, Luxembourg.
11. For Italy, share of irrigation water in total agriculture water use, for 1998.
12. For Hungary, the change in irrigated area is –39%.
13. For the Slovak Republic, the change in irrigated area is –49%.
14. For the Czech Republic, the change in irrigated area is –54%.

Source: FAOSTAT, 2006; OECD Agri-environmental Indicators Questionnaire (unpublished); *OECD Environmental Data Compendium 2004*, Paris, France. For Spain, the source is "Anuario de estadistica agroalimentaria".

In aggregate the OECD area irrigated rose by 8% compared to a reduction of 3% in the total agricultural area between 1990 and 2003 (Figure 1.6.3). For some countries where irrigation plays a key role in the agricultural sector and farming is also a major water user in the economy (**Australia, Greece, Korea, Portugal, Spain** and **Turkey**), the growth in agricultural water use over the past decade has been substantially above that compared to other water users (Figure 1.6.1).

The value of production from irrigated agriculture has a high and growing share in agricultural production value (in excess of 50%) and value of exports (more than 60%) in a number of OECD countries, *e.g.* **Italy, Mexico, Spain** and the **United States** (crop sales only). Agricultural production projections over the next 10 years (Section 1.1), suggest that demand for water from agriculture will increase together with growing competition from other water users. This has ramifications for those countries where irrigated agriculture is already important (**Australia, Mexico, Portugal, Spain**, the **United States**), but also for some countries which have not usually been concerned with water conservation. In **New Zealand**, for example, demand for irrigation water is projected to increase by nearly 30% between 2000 and 2010, which has raised concerns over maintaining water flows for environmental needs in drier regions (Chapter 3).

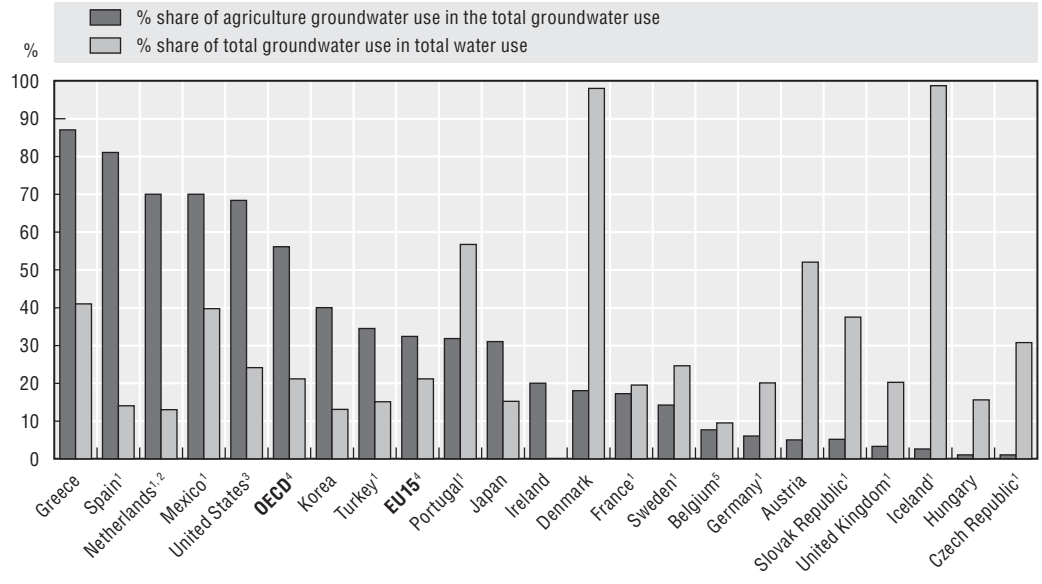
Trends and projections in agricultural water use are of particular concern for groundwater resources. Agriculture's share in total groundwater utilisation is above 30% in a third of OECD countries (Figure 1.6.4). While there is little cross country OECD data on trends in agricultural groundwater use, the information that does exist suggests that irrigated agriculture is drawing an increasing share of its supplies from aquifers rather than surface water. For example, groundwater provides around 40% of supplies for irrigated agriculture in the **United States**, and between 1995-2000 groundwater extraction for irrigation rose by 16% compared to a decrease of 5% from surface water (Chapter 3). The use of groundwater by irrigators is substantially above recharge rates in some regions (*e.g.* in **Australia, Greece, Italy, Mexico** and the **United States**) where it is impeding the economic viability of agricultural and rural economies in some of these regions. In most European countries surface water is the main source of agricultural water use, but the use of groundwater resources is increasing and accounts for over 30% of total groundwater use in, **Greece, Netherlands, Portugal, Spain** and **Turkey** (Figure 1.6.4).

Over exploitation of water resources by agriculture has damaged aquatic ecosystems, including harming recreational and commercial fishing activities, especially during periods of drought, although data on these impacts are limited. **Australia** and some OECD countries in **North America** and **Europe** have experienced problems in retaining minimum river flows as a result of overexploitation by irrigated agriculture (Chapter 2). In other cases, for example **Turkey**, irrigation projects have altered the ecology of entire regions (OECD, 1999). Therefore, monitoring minimum water flow rates in rivers is becoming a key part of environmental planning in river basins.

Government support for irrigation is widespread across OECD countries, covering the totality or part of the irrigation infrastructure construction costs and those associated with water supply pricing (Figure 1.6.3, Chapter 2; Chapter 3). However, some countries use full cost recovery for water provision to farmers (**Austria, Netherlands**, Figure 1.6.3, Chapter 2), or are beginning to implement water policy reform programmes that seek to reduce water subsidies (*e.g.* **Australia, Mexico, Spain**), and in some cases use water associations and voluntary measures (*e.g.* **Japan**). In addition, in a number of countries energy subsidies to agriculture

Figure 1.6.4. **Share of agricultural groundwater use in total groundwater use, and total groundwater use in total water use**

2002



StatLink http://dx.doi.org/10.1787/287204233686

1. Data of 1994 are used to replace missing data of 2002 for: France, Ireland, Portugal. Data of 1995 are used to replace missing data of 2002 for: Germany, Netherlands, Spain and Sweden. Data of 1997 are used to replace missing data of 2002 for: Czech Republic, Greece, Iceland, Mexico, Slovak Republic and Turkey. Data for 2000 are used to replace missing data of 2002 for: United Kingdom.
2. *Source:* Chapter 3, Netherlands country section.
3. United States: groundwater for irrigation is used, as data on total agricultural groundwater are unavailable.
4. The EU15 and OECD data must be interpreted with caution, as they consist of totals using different years across countries, and do not include all member countries. EU15 excludes: Finland, Italy, Luxembourg. OECD excludes: Australia, Canada, Finland, Italy, Luxembourg, New Zealand, Norway, Poland, Switzerland.
5. Year 2000.

Source: OECD, *Environmental Data Compendium 2004*, Paris, France; OECD Agri-environmental Indicators Questionnaire, unpublished.

have lowered costs for extracting water, especially from groundwater sources (*e.g.* **Mexico**, Chapter 3). By subsidising irrigation infrastructure, water supply prices and the energy costs to power irrigation facilities, this can act as a disincentive to reducing water use and using water more efficiently (OECD, 1998). At the same time investment to rehabilitate and renew irrigation infrastructure can help reduce water loss and contribute to efficient water distribution.

The low uptake of water efficient irrigation technologies, such as drip emitters (Section 1.9), and the poor maintenance of irrigation infrastructure (*e.g.* canals) has, for some countries, led to inefficiencies in water use and water losses through leakages leading to an increase in water application rates per hectare irrigated. Estimates for **Mexico**, for example, show that only 45% of water extracted reaches irrigated fields (Chapter 3). Even so, overall the OECD average water application rate per hectare irrigated decreased by 9% over the period 1990-92 to 2001-03 (Figure 1.6.3). In the **United States**, for example, efficiency gains have been made in irrigation water use over the 1990s, with a decline in per hectare application rates by 10% (Figure 1.6.3, Hutson *et al*., 2004; Chapter 3). Reduction in water application rates per hectare irrigated have also been achieved in other countries where irrigated agriculture is important (notably in **Australia**, but also to a lesser extent in **Mexico**, **Spain** and the **United States** (Figure 1.6.3), but irrigation water use efficiency has deteriorated for others (**Greece, Portugal** and **Turkey**) (Figure 1.6.3).

The growing incidence and severity of droughts over the past decade in some regions, reflects climate change and climate variability with an increasing pressure on farming operating in drier and semi-arid areas. Climate change impacts are both a pressure to install irrigation to mitigate against droughts, and also as a pressure to use water more efficiently in areas already irrigated. In **Australia**, for example, use of water resources rose by 24% over the period 1993-95 to 2000 (Figure 1.6.1), a period during which average rainfall levels have declined in major farming regions (Chapter 3).

1.6.2. Water quality

Indicator definitions:

- Nitrate and phosphate contamination derived from agriculture in surface water and coastal waters.
- Monitoring sites in agricultural areas that exceed recommended drinking water limits for nitrates and phosphorus in surface water and groundwater (nitrates only).
- Monitoring sites in agricultural areas that exceed recommended drinking water limits for pesticides in surface water and groundwater.
- Monitoring sites in agricultural areas where one or more pesticides are present in surface water and groundwater.

Concepts and interpretation

Agricultural pollution of water bodies (rivers, lakes, reservoirs, groundwater and marine waters) relates to firstly, the contamination of drinking water, and secondly, the harmful effects on aquatic ecosystems, resulting in damage to aquatic organisms, and costs for recreational activities (*e.g.* swimming) and commercial fisheries in both fresh and marine waters.

The impact of farming practices on water quality can be significant as a "non-point" source of pollution (*i.e.* from spreading fertilisers and livestock manure across fields and small livestock farms), especially as industrial and urban sources of "point pollution" are declining in most cases, although some agricultural "point pollution" sources are of concern, such as large intensive livestock operations. Nutrients (mainly nitrogen and phosphorus from fertilisers and livestock), pesticides, soil sediments, salts and pathogens are the main pollutants transmitted to water bodies from agriculture, through soil run-off and leaching, but also discharges from livestock operations and irrigation systems.

Most OECD countries have monitoring networks to measure the actual state of water pollution of water bodies, while some countries use risk indicators which provide estimates, usually based on models of contamination levels. However, monitoring of agricultural pollution of water bodies is more limited with just over a third of OECD member countries monitoring nutrient pollution and even fewer countries tracking pesticide pollution (Annex II.A2, Section II, *Background and Scope of the Report*). Certain farm pollutants are recorded in more detail and with greater frequency (*e.g.* nutrients, pesticides), whereas an indication of the overall OECD situation for water pollution from pathogens, salts and other agricultural pollutants is unclear (Chapter 2). Moreover, pollution levels can vary greatly between OECD countries and regions depending mainly on soil and crop types, agro-ecological conditions, climate, farm management practices, and policy.

The limitations to identifying trends in water pollution originating from agriculture are in attributing the share of agriculture in total contamination and identifying areas vulnerable to agricultural water pollution. In addition, differences in methods of data collection and national drinking and environmental water standards (OECD website database) hinder comparative assessments, while monitoring agricultural water pollution is poorly developed, especially for pesticides, in a number of countries (**Australia, Italy, Japan, New Zealand**). The extent of agricultural groundwater pollution is generally less well documented than is the case for surface water, largely due to the costs involved in sampling groundwater, and because most pollutants take a longer time to leach through soils into aquifers and, hence, critical drinking water and environmental standards have not yet been reached.

Changes in nutrient balances (Section 1.2) and pesticide use (Section 1.3.1) are the key ***driving forces*** that are linked to water quality indicators which describe the ***state*** of water quality in agricultural areas and define the contribution of nutrient and pesticide pollution originating from agricultural activities. Pesticide risk indicators (Section 1.3.2) are also important, especially as they relate to the toxic risks of pesticides on aquatic ecosystems. Adaptation of a range of farm management practices (Section 1.9) are the ***response*** by farmers to reduce pollutant run-off from farmland into water bodies.

Recent trends

The overall pressure of agriculture on water quality in rivers, lakes, groundwater and coastal waters eased over the period 1990 to mid-2000s due to the decline in nutrient surpluses and pesticide use for most OECD countries. Despite this improvement absolute levels of agricultural nutrient pollution remain significant in many cases. With point sources of water pollution (*i.e.* industrial and urban sources) falling more rapidly than for agriculture over the 1990s and effectively controlled in most situations, the share of agriculture (*i.e.* non-point source of pollution) in nutrient pollution of water has been rising even though absolute levels of pollutants have declined in many cases. Similarly for pesticides absolute levels of run-off remain high.

Nearly a half of OECD countries record that nutrient and pesticide concentrations in surface water and groundwater monitoring sites in agricultural areas exceed national drinking water limits for nutrients and pesticides. But the share of monitoring sites of rivers, lakes and marine waters that exceed recommended national limits or guidelines for environment and recreational uses is much higher, with agriculture a major cause of this pollution in many cases. This is evident in the widespread problem of eutrophication reported in surface water across OECD countries, and the damage to aquatic organisms from pesticides. Estuarine and coastal agricultural nutrient pollution is also an issue in some regions causing algal blooms (*i.e.* "red tides" or "dead zones"), damaging marine life, including commercial fisheries in coastal waters adjacent to **Australia, Japan, Korea**, the **United States**, and **Europe**, mainly the Baltic, North Sea, and Mediterranean (see country sections in Chapter 3).

With respect to groundwater, however, agriculture is now the major and growing source of pollution across many OECD countries, especially from nutrients and pesticides, largely because other sources of pollution have been reduced more rapidly than for agriculture, although evidence of groundwater pollution is limited (Chapter 3). This is a particular concern for countries where groundwater provides a major share of drinking water supplies for both human and livestock populations, for example, **Denmark**, and also as natural recovery rates from pollution can take many decades, in particular, for deep aquifers. There is also some

evidence of increasing pollution of groundwater from pesticides despite lower use in many cases, largely explained by the long delays pesticides can take to leach through soils into aquifers (Chapter 3).

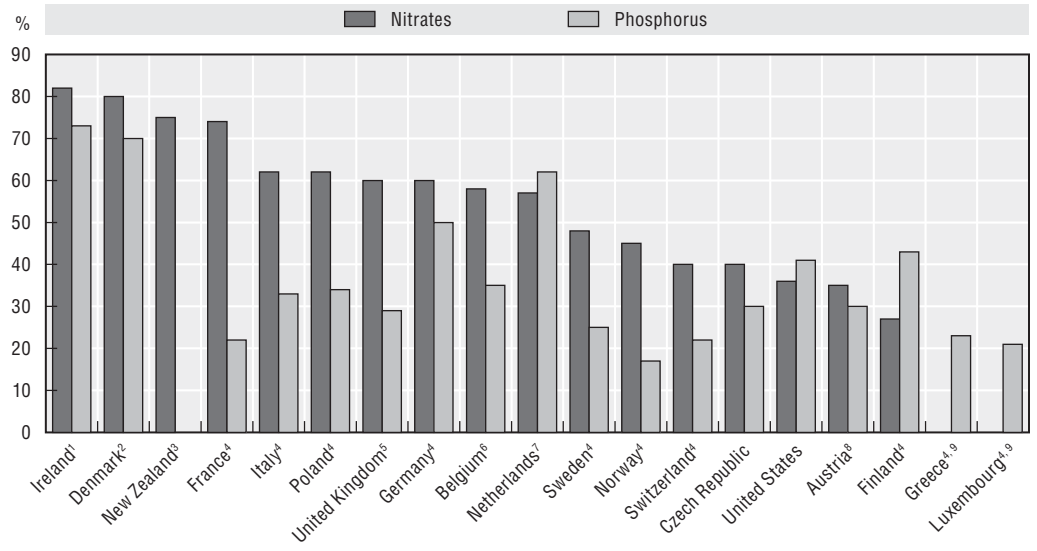
The economic cost of agricultural water pollution is high in many cases. Treating water to remove nutrients and pesticides to ensure water supplies meet drinking standards is significant in some OECD countries. In the **United Kingdom**, for example, the overall economic cost of water pollution from agriculture was estimated in 2003/04 to be around EUR 345 million annually contributing over 40% of all water pollution costs (Chapter 3). Eutrophication of marine waters also imposes high economic costs on commercial fisheries for some countries (*e.g.***Korea, United States**).

Nitrates

For many countries the share of agriculture in the total pollution of surface water by nitrates is over 40% (Figure 1.6.5). Evidence of the contribution of agriculture in groundwater pollution is limited, but some information suggests it may be lower than for rivers and lakes but increasing. Agriculture's contribution of nitrogen loadings into estuarine and coastal water is also above 40% for many countries, and often reported as the main cause of eutrophication

Figure 1.6.5. **Share of agriculture in total emissions of nitrates and phosphorus in surface water**

Mid-2000s



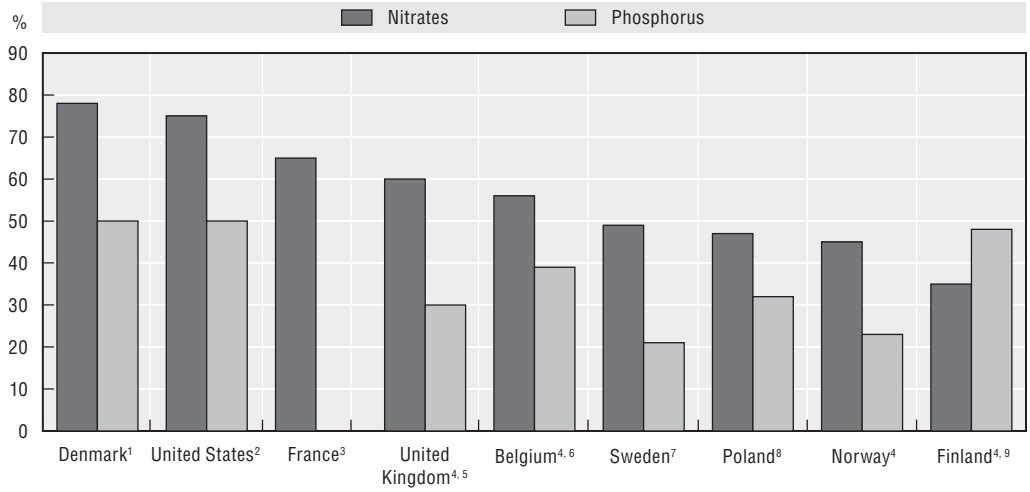
StatLink http://dx.doi.org/10.1787/287220150527

1. 2004, see Ireland, Chapter 3.
2. Phosphorus (2002), percentage refers to Danish lakes only.
3. Data for nitrate contamination of rivers and streams, total input to surface waters from agriculture non-point source pollution. Data for phosphorus not available. *Source:* New Zealand Parliamentary Commissioner for the Environment, "Growing for good, intensive farming, sustainability and New Zealand's environment", October 2004, p. 98, *www.pce.govt.nz*.
4. Data for mid-1990s for Finland, France, Germany, Greece, Italy, Luxembourg, Norway, Poland, Sweden, Switzerland. OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France.
5. *Source:* Chapter 3, United Kingdom.
6. Flanders only, 2001.
7. Chapter 3, Netherlands, 2002.
8. Value for 2000.
9. Data for nitrate emissions are not available.

Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; OECD Agri-environmental Indicators Questionnaire, unpublished.

Figure 1.6.6. **Share of agriculture in total emissions of nitrates and phosphorus in coastal water**[1]

Average 2000-02



StatLink http://dx.doi.org/10.1787/287242542570

1. Data refer to 2002.
2. Data refer to 2000.
3. *Source:* Chapter 3 represents nitrates discharged from the River Seine into "la Manche" (the Channel). Data refer to 2000.
4. Data on nitrates and phosphorus are from the OECD Agri-environmental Indicators Questionnaire, unpublished, for Belgium, Finland, Norway and the United Kingdom.
5. Nitrate estimated at between 50-70% and between 30-40% for phosphorus. *Source:* OECD Agri-environmental Indicators Questionnaire, unpublished.
6. Flanders only, year 2000.
7. Data refer to 2000 and to anthropogenic load, agriculture contributed to 21% of the total phosphorus load.
8. Includes a range of 45-50% for nitrogen and 30-35% for phosphorus.
9. Data refer to 1997-2001.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished; OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France.

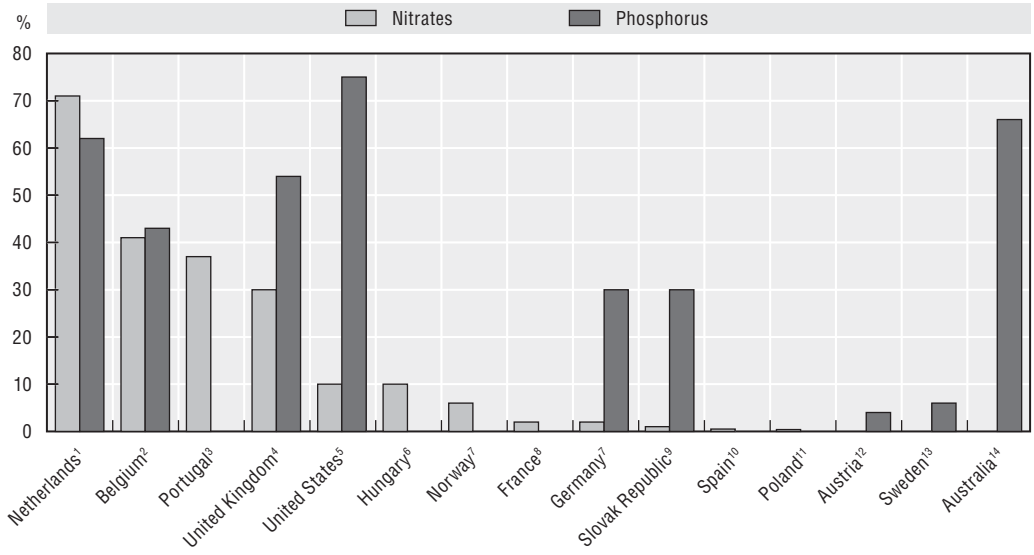
(Figure 1.6.6). But the share of agricultural nitrates in surface and coastal waters can reveal significant fluctuations depending on annual river flows, such as in the **United Kingdom** (Chapter 3).

The share of monitored sites in agricultural areas with nitrates in surface water and groundwater above national drinking water threshold values is for many countries below 10%, although for a few countries the share is above 25% (**Belgium, Netherlands, Portugal** and **United Kingdom**) (Figures 1.6.7 and 1.6.8). Also the share of monitored sites in agricultural areas with nitrates in groundwater above drinking water standards tends to be higher than for surface water, notably for **Austria, France, Germany, Slovak Republic, Spain** and the **United States**, but not for **Australia, Belgium, Hungary, Netherlands, Norway, Portugal** and the **United Kingdom** (Figures 1.6.7, 1.6.8).

There is a lack of consistent data to show OECD trends for agricultural nitrate pollution of water, but the limited information that exists (Chapter 3) suggests a declining number of monitoring sites in farming areas over the 1990s exceeding national drinking water threshold values (**Austria, Belgium, Germany, Norway, Sweden, Switzerland**), but a stable or rising trend for others (**France, Japan, New Zealand, Spain, the United Kingdom**). The overall decline in OECD nitrogen balances over the 1990s confirms these trends (Section 1.2), except in those cases where nitrogen surpluses are continuing to rise (**Canada, Hungary, Ireland,**

Figure 1.6.7. **Share of monitoring sites in agricultural areas exceeding national drinking water limits for nitrates and phosphorus in surface water**

Average 2000-02



StatLink http://dx.doi.org/10.1787/287246533608

1. Late 1990s. Data taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France.
2. Flanders only, 2001-02.
3. Data refer to average 2000-03, see Chapter 3. Data for phosphorus not available.
4. Between 2000-02 around 30% of rivers in England and Wales have nitrate levels in excess of 30 mg NO_3/l, but below the EU drinking water standard of 50 mg NO_3/l. Data for phosphorus are for England and Wales.
5. United States: value applies to share of monitoring sites above Federal guidelines to prevent excess algal growth, and refers to average of 1995-2005.
6. Data refer to average 2000-02, applies to all surface water monitoring points. Data for phosphorus are not available.
7. Data refer to 2000. Data for phosphorus are not available.
8. Data refer to 2000-01, and data for phosphorus are not available.
9. Data for 2002.
10. For Spain the data refer to average 2001-03. Data for phosphorus are not available.
11. Monitoring data between 1990-99. See Chapter 3. Data for nitrates are 0.38%.
12. Data refers to 2000-01. Data for nitrates are not available.
13. Sweden: value for nitrates is not available and for phosphorus 6% for lakes in the national and regional environment monitoring programme for 2000.
14. *Source:* See Australian country section, Chapter 3, applies to a sample of river basins. Data for nitrates are not available.

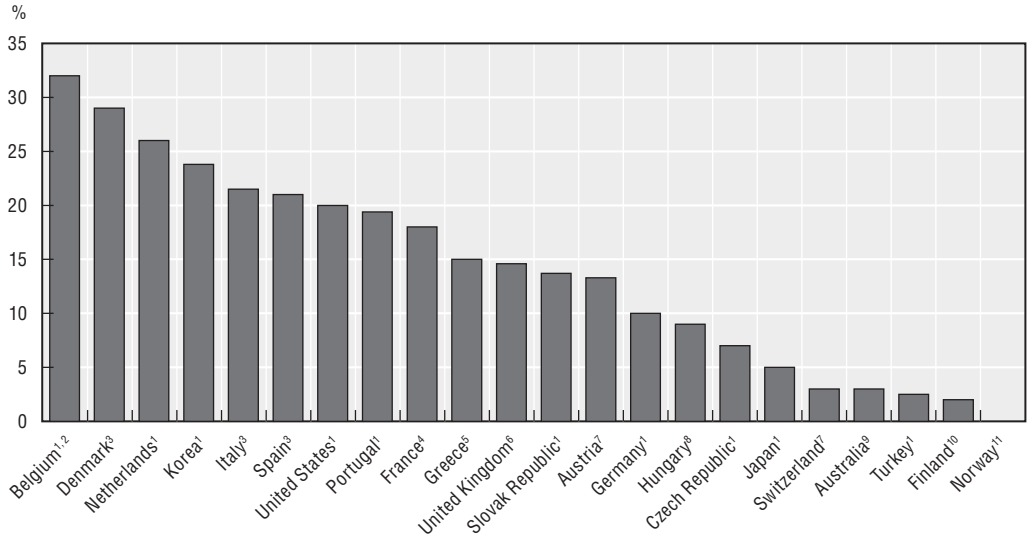
Source: OECD Agri-environmental Indicators Questionnaire, unpublished; OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France.

New Zealand, Portugal, United States). Also a number of **EU15** countries have at various times over the past decade contravened the 1991 EU *Nitrate Directive*, which seeks to reduce agricultural pollution in "nitrate vulnerable zones".

Monitoring of sites in agricultural areas in terms of detecting pollution above recommended environmental and recreational use limits is much poorer across OECD countries compared to monitoring of drinking water. Of the evidence that exists this reveals a much higher level of contamination of water compared to drinking water. For example, in the **United Kingdom** (England and Wales only) almost 80% of water catchments are affected by eutrophication, and over 80% of aquatic ecosystems designated as sites of special scientific interest show symptoms of being eutrophic with a loss of aquatic species (Chapter 3).

Figure 1.6.8. **Share of monitoring sites in agricultural areas exceeding national drinking water limits for nitrates in groundwater**

Average 2000-04



StatLink http://dx.doi.org/10.1787/287267751668

1. Data refer to average of 1995-2005.
2. Belgium (Flanders only).
3. Data refer to average 2002 and 2003.
4. Data refer to 2001.
5. Data refer to average 2001-02, with a range of 10-20%, see Chapter 3.
6. Data refer to 2004.
7. Data refer to 2002.
8. Data refer to average 2000-02 (Chapter 3) applies to all surface water monitoring points.
9. See Chapter 3 for Australia. Groundwater in intensively farmed areas of north-eastern Australia.
10. Data refer to 2002, estimated for shallow wells at 2% and for aquifers 1.5%.
11. Norway (National environmental monitoring programme) reported 0% for 1985-2002.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished; OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France.

Phosphorus

Overall OECD trends in agricultural phosphorus pollution of water bodies over the 1990s are similar to those for nitrates. Agriculture is a major source of phosphorus in surface water (Figure 1.6.5) and coastal waters accounting for a share of over 40% in some countries (Figure 1.6.6). In most cases, however, agriculture's contribution of phosphorus to water bodies is lower than for nitrates, markedly so for **Belgium, France, Italy, Norway, Poland, Sweden** and **Switzerland** (Figures 1.6.5 and 1.6.6).

For those countries reporting the number of monitored sites in agricultural areas that measure above drinking water standards for phosphorus, the number tends to be higher than for nitrates, significantly in the cases of **Germany**, the **Slovak Republic**, the **United Kingdom** and the **United States** (Figure 1.6.7). This might reflect the long time lags associated with phosphorus transport through soils into water relative to nitrogen, especially as overall trends in OECD agricultural phosphate balances imply a lowering of pressure on water bodies from this pollutant (Section 1.2). For example, the phosphorus surplus (P tonnes) from farming in the **United Kingdom** fell by over 20% between 1990 and 2004 (Section 1.2), however, concentrations in rivers did not change with a steady 54% of monitoring sites registered above drinking water standards (Chapter 3).

As with nitrates, there is poor information on OECD trends for phosphates in water supplies over the past decade. For a few countries, however, data indicate a variable picture of the number monitored sites in farming areas where phosphorus exceeded national drinking water threshold values, with improvement in **Austria** and **Belgium**, no clear trend in **Norway**, and a stable situation in the **United Kingdom** (Chapter 3).

Similarly, information of the share of monitored sites in agricultural areas above environmental and recreational use standards for phosphorus in water supplies is poor across OECD countries, as for nitrates. However, in the **United States**, for example, more than 75% of farmland rivers had phosphorus concentrations above recommended levels to prevent algal blooms.

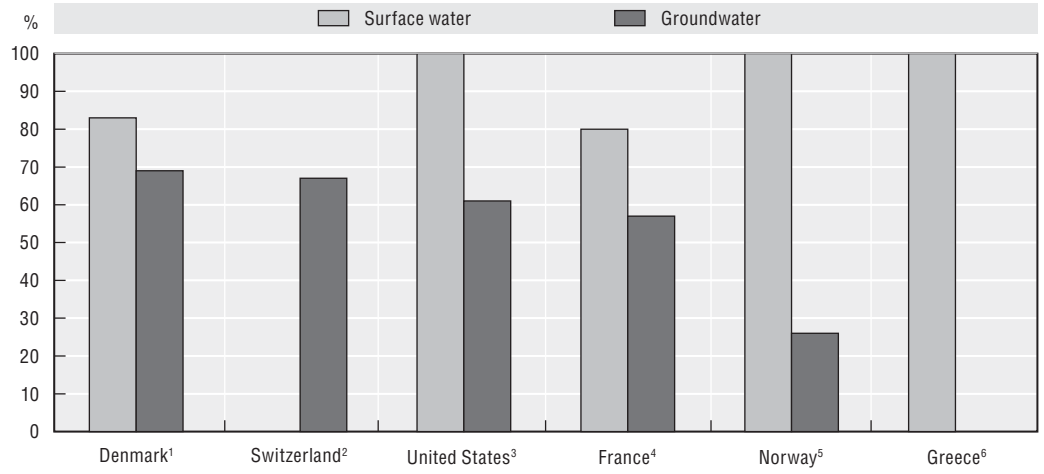
Pesticides

The presence of pesticides in surface water and groundwater is widespread across OECD countries, with the share of monitored sites with one or more pesticides above 60% of the total in most cases, and reaching a 100% for **Greece, Norway** and the **United States** for surface water (Figure 1.6.9). But less than a half of OECD countries monitor pesticides in water bodies.

The share of monitored sites where pesticide concentrations are above drinking water standards for surface and groundwater supplies are generally lower than for nutrients. But concerns remain for groundwater with shares above 10% for some countries, including

Figure 1.6.9. **Share of monitoring sites in agricultural areas where one or more pesticides are present in surface and groundwater**

Average 2000-03



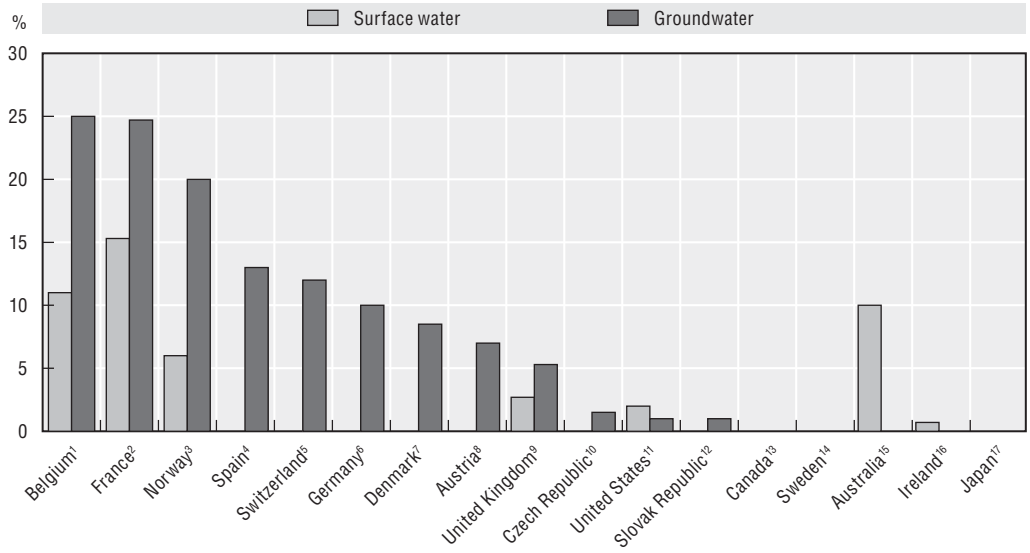
StatLink http://dx.doi.org/10.1787/287348331384

1. Data refer to the period 1998-2003.
2. Data for 2002.
3. Data 1992-98. Value for surface water (figures in brackets apply to groundwater) show 1-2 pesticides present in 8% (29%) of monitoring sites; 3-4 pesticides in 18% (21%) of sites; and more than 5 pesticides in 74% (11%) of sites. For surface water (farmland streams) 80% of monitoring sites have concentrations above aquatic life water guidelines.
4. *Source:* French country section, Chapter 3, data 2002.
5. Data 1995-2002, with concentration levels for surface water declining in most locations. For groundwater share for pesticide presence applies to farmers' drinking water wells, while pesticide concentration in groundwater is 2% for those aquifers supplying more than 100 people.
6. Data 1999-2000.

Source: OECD, Agri-environmental Indicators Questionnaire, unpublished.

Figure 1.6.10. **Share of monitoring sites in agricultural areas exceeding national drinking water limits for pesticides in surface water and groundwater**

Average 2000-02



StatLink http://dx.doi.org/10.1787/287360620862

1. Data 2000-02. Flanders region only. Atrazine only for surface water. Regional variation show concentrations ranged between 13% to 32%, with 10% of monitoring sites in excess of 0.5 μg/l compared to drinking water standard of 0.1 μg/l.
2. National data. Average poor and poor status. See Chapter 3.
3. Data applies only to monitoring locations in high risk pollution sites. Data 1995-2002, with concentration levels for surface water declining in most locations. For groundwater % share for pesticide presence applies to farmers' drinking water wells, while pesticide concentration in groundwater is 2% for those aquifers supplying more than 100 people.
4. *Source:* OECD (2004), *Environmental Performance Review of Spain*, Paris, France. No data for surface water.
5. Data 2002, apply to water catchments under arable farming. No data for surface water.
6. *Source:* German country section, Chapter 3, data 1995. No data for surface water.
7. *Source:* EEA (2005), data 2000. No data for surface water.
8. Data 1990-2001. Atrazine only. In 1992-94 share of monitoring sites with pesticide concentration above drinking water standard for groundwater was 20%. No data for surface water.
9. For surface water, data applies to England and Wales, average 2000-02 for atrazine samples over 100 mg/l. For groundwater, data apply to average 2000-02 for monitoring sites in arable land areas, the percentage is 4% for managed grassland.
10. Data refer to 2003. No data for surface water.
11. Data 1992-98. Value for surface water (figures in brackets apply to groundwater) show 1-2 pesticides present in 8% (29%) of monitoring sites; 3-4 pesticides in 18% (11%) of sites; and more than 5 pesticides in 74% of sites. For surface water (farmland streams) 80% of monitoring sites have concentrations above aquatic life water guidelines.
12. Data 1985-2002. No data for surface water.
13. Rural wells, see Chapter 3. No data for surface water.
14. Data 1998-2002, measurement for only one region, Vemmenhög, 0% for groundwater. No data for surface water.
15. *Source:* Australia country section, Chapter 3. Cotton-growing areas of Eastern Australia only. No data for groundwater.
16. Ireland, 2004. *Source:* Environment Protection Agency (2005), *The quality of drinking water in Ireland: a report for the year 2004*, Wexford, Ireland. Applies to exceedence levels in public water supplies.
17. Only for surface water (rivers, lakes and coastal water), 0.1% average 1998 to 2005, see country section, Chapter 3.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished; EEA (2006).

Belgium, France, Germany, Norway, Spain and **Switzerland** (Figure 1.6.10), while **Italy** reports rising concentrations of pesticides in groundwater at the same time as pesticide use has increased (Section 1.3). Pesticides are also reported as a common pollutant in coastal waters for some countries (**France** and **Mexico**, see Chapter 3), with risks to human health from fish consumed from these waters, of particular concern for **Mexico** where pesticide use rose over the 1990s (Section 1.3).

The general trend in OECD pesticide use would support the conclusion that there is a constant, or even decreasing pressure on water quality from pesticides (Section 1.3.1). But caution is required when linking trends in pesticide use to water pollution, as different pesticides pose different types and levels of risks to aquatic environments and drinking water (Section 1.3.2). Evidence from pesticide risk indicators over the 1990s (Section 1.3.2), shows that for aquatic species the risks of pesticide toxicity remained unchanged in **Denmark** and declined in **Belgium, Germany** and the **Netherlands** (since 1999).

Another concern with pesticide pollution of water bodies relates to highly persistent and toxic pesticides such as DDT. In most cases, in OECD countries such pesticides have been banned for many decades, but are, nevertheless, still being detected at levels that are harmful to aquatic organisms. This is the case, for example, in **France**, the **United States**, and **Mexico**, although in the latter country the ban on such pesticides was more recent.

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1.7. AIR

KEY TRENDS

Farming accounted for about a quarter of total OECD acidifying emissions, 8% of the use of potential ozone depleting substances, and 8% of greenhouse gases (GHGs) (2002-04). But shares are higher for specific air pollutants: over 90% of anthropogenic ammonia emissions; nearly 75% of methyl bromide use, and for GHGs about 70% of nitrous oxide and over 40% of methane. Agricultural multi-air pollutants have contributed to multi-environmental effects through acidification, eutrophication, ozone depletion, and climate change, as well as affecting the health of human populations.

Total OECD agricultural ammonia emissions grew by 1% over the period 1990-92 to 2001-03, compared to the overall reduction of acidifying gases, mainly due to lower emissions from industrial and energy sectors. Some countries (notably Denmark and Germany and Spain) will need to make reductions in ammonia emissions to meet the 2010 targets agreed under the *Gothenburg Protocol*. But for more than two-thirds of OECD countries, agricultural ammonia emissions declined, with many of these countries reducing emissions by more than 10%.

The growth in OECD ammonia emissions is mainly linked to increasing livestock numbers and to a lesser extent greater fertiliser use, notably in Canada, Italy, Korea, Portugal, Spain and the United States. Where reductions in ammonia emissions have been achieved this is usually linked to using a mix of policies (*e.g.* nitrogen taxes, payments for manure storage) and a high adoption rate of nutrient management plans, in addition, to a decline in livestock numbers and lower fertiliser use.

Methyl bromide use in OECD countries have met the 70% reduction target (from 1991 levels) set for 2003 under the Montreal Protocol, but there was a substantial increase in OECD methyl bromide use in 2004 compared to 2003, largely accounted for by the United States, and, to a lesser extent Australia and Japan. Hence, for these countries to achieve a complete phase-out of methyl bromide in 2005, as agreed under the *Montreal Protocol*, will require a substantial effort.

For methyl bromide use, while OECD countries have made considerable progress in meeting reduction targets under the *Montreal Protocol*, Critical Use Exemptions (CUEs) have been agreed for 2005 to give farmers and other users additional time to develop substitutes. Granting CUEs may impede the effectiveness of achieving reduction targets and acting as a disincentive to seek alternatives.

For ***GHG emissions*** there are no specific targets for agriculture under the *Kyoto Protocol*. Nearly 75% of total OECD agricultural GHG emissions (2002-04), were accounted for by the EU15 and the United States. EU15 emissions declined by 7% (31 million tonnes of GHGs in carbon dioxide equivalents CO_2), while they rose by 1% (5 million tonnes CO_2 equivalent) in the United States.

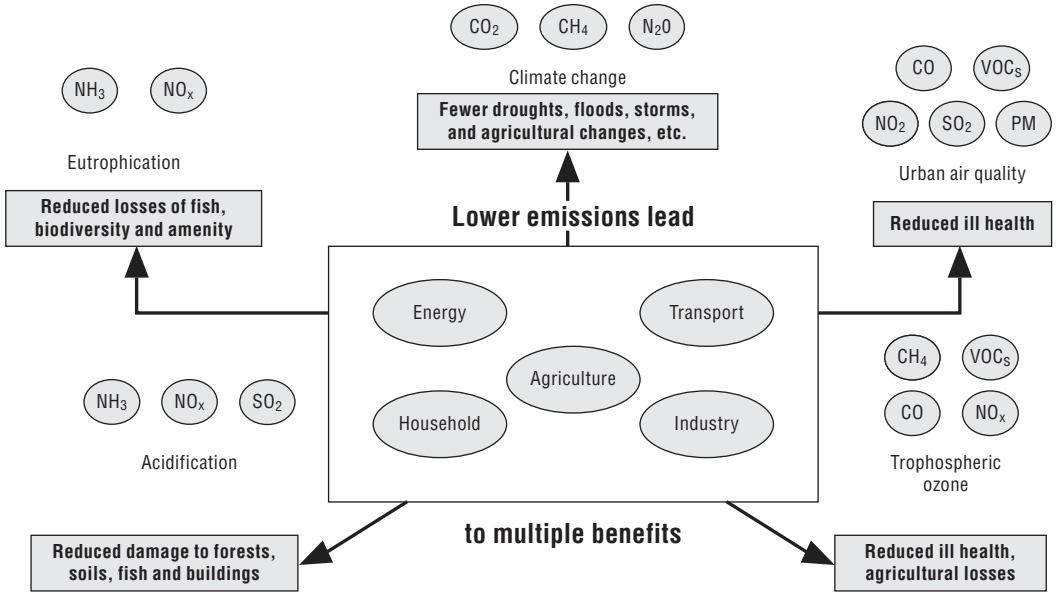
The largest increase in agricultural GHG emissions (over 5%) occurred in Australia, Canada, New Zealand, Portugal and Spain, which together increased GHG emissions by 26 million tonnes CO_2 equivalent, and now these countries account for over 20% of total OECD agricultural GHG emissions. But for the majority of OECD countries GHG emissions decreased between 1990 and 2004. Changes in GHG emissions are largely driven by an expansion (decrease) in livestock production (methane from manure) and crop production (nitrous oxide from fertiliser use), although in some countries (Australia, Mexico) land clearing, mainly for agricultural use, makes an important contribution to national total GHG emissions.

Although ***agriculture represents a small share in total OECD GHG emissions,*** the share (2002-04) was over 15% for Australia, France, Iceland and Ireland. For New Zealand the share is almost 50%, although its contribution to total OECD agricultural GHG emissions is only 3%. Many countries are adopting strategies that seek to encourage farmers to alter their farming practices, such as changing livestock manure disposal methods and soil tillage practices, which can lower GHG emission rates per unit output volume and which can also have co-benefits in reducing ammonia emissions and increasing soil carbon stocks.

Background

This section examines how agricultural activities impact on air quality, through emissions of ammonia (NH_3) and greenhouse gases (methane CH_4, nitrous oxide N_2O and carbon dioxide CO_2). The environmental impacts of these agricultural emissions should be viewed in the broader context of other pollution sources (*e.g.* industry, transport) and considered in terms of the chemical reactions between different air pollutants in the atmosphere ("multi-pollutants", *e.g.* sulphur dioxide, carbon dioxide) and the resultant effects on the environment ("multi-effects", *e.g.* acidification, eutrophication) (Figure 1.7.1). The section also discusses agriculture's use of methyl bromide, a pesticide, which is an ozone depleting substance.

Figure 1.7.1. **Impacts of agriculture on air quality: Multi-pollutants, multi-effects**



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Note: CH_4 – methane ; CO_2 – carbon dioxide ; NH_3 – ammonia ; N_2O – nitrous oxide ; NO_2 – nitrogen dioxide; NO_x – nitrogen oxides; PM – particulate matter; SO_2 – sulphur dioxide ; VOC_s – volatile organic compounds.

Source: EEA (2000).

1.7.1. Ammonia emissions, acidification and eutrophication

Indicator definition:

- Share of agricultural ammonia emissions in national total ammonia (NH_3) emissions.

Concepts and interpretation

Ammonia (NH_3) emissions are associated, as a driving force, with two major types of environmental issues: acidification and eutrophication (Figure 1.7.1). Ammonia along with sulphur dioxide (SO_2) and nitrogen oxides (NO_x) contribute to *acidification* of soil and water when it combines with water in the atmosphere or after deposition. Excess soil acidity may be damaging to certain types of terrestrial and aquatic ecosystems. As a source of nitrogen, deposition of ammonia can also raise nitrogen levels in soil and water, which may contribute to *eutrophication* in receiving aquatic ecosystems.

Along with acidification and eutrophication, agricultural NH_3 emissions may be a significant contributor to the formation of aerosols in the atmosphere which may impair human health (*i.e.* worsen respiratory conditions), visibility, and climate (Lynch and Kurshner, 2005). At high concentrations, and near the source, it produces an unpleasant odour which may also affect human and animal health (AAFC, 1998).

OECD European countries have adopted the *1999 Gothenburg Protocol* with agreed national ammonia emission ceiling targets (Table 1.7.2) (together with other gas emissions not usually associated with farming, such as sulphur dioxide) in an effort to reduce environmental problems associated with soil acidification, eutrophication and ground-level ozone under the *Convention on Long-range Transboundary Air Pollution* (LRTAP, see UNECE, 1979). **Canada** and the **United States** are also signatory countries to the Protocol but have not agreed on emission targets. The European Communities (2001) Directive on "*National Emission Ceilings for Certain Atmospheric Pollutants*" endorses the same national emission ceilings as under the "Protocol" for all **EU** countries, except **Portugal** (Table 1.7.2). For those countries under the *Gothenburg Protocol*, the ammonia emission data used in this section are drawn from UNECE sources (UNECE/EMEP, 2004), and national sources for other countries (Figure 1.7.2).

As part of the effort to reduce ammonia emissions from agriculture, in many OECD countries considerable research has been undertaken to validate and improve the emission factors that are used in estimating the level of ammonia emissions. In addition, effort has been undertaken to develop technologies and management practices to reduce the level of ammonia emissions, particularly relating to how manure is managed from storage through to spreading. The uptake of these technologies and practices has been encouraged through government farm extension services and some financial assistance provided to farmers (Section 1.9, and OECD, 2003a and 2004a).

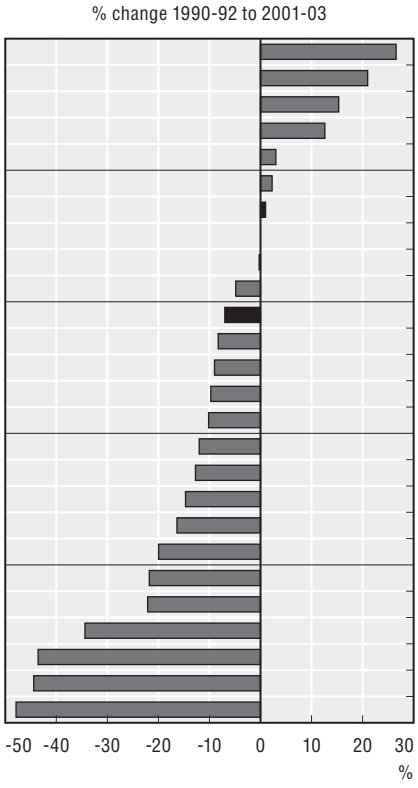
The agricultural ammonia emission indicator is linked to trends in nitrogen balances (Section 1.2) as ***driving forces*** on the ***state*** or concentrations of *nitrates in water bodies* (Section 1.6.2) and acidifying pollutants in the air. The agriculture sector in many OECD countries is obliged to ***respond*** by reaching national ammonia emission ceilings agreed under the *Gothenburg Protocol*, through for example the adoption of nutrient management practices (Section 1.9).

Recent trends

The growth in total OECD anthropogenic NH_3 emissions is largely due to agriculture (1990-2003), which accounts for more than 90% of emissions across most OECD countries (Figure 1.7.2). Total OECD emissions of acidifying gases (SO_2, NO_x and NH_3) are declining however, mainly due to a substantial reduction in SO_2 emissions from industry and the energy sector (Figure 1.7.3, Table 1.7.1). But with the increase in NH_3 emissions over the 1990s, agriculture's share in total acidifying gases has risen (Table 1.7.1). For some countries agricultural NH_3 emissions have increased by over 10% (**Korea, Portugal, Spain** and the **United States**), mainly linked to the substantial rise in livestock numbers in these countries, and to a lesser extent increases in fertiliser use (Figures 1.7.2 and 1.7.4).

But for more than two-thirds of OECD countries, agricultural ammonia emissions declined, with many of these countries reducing emissions by more than 10%. The large cut in emissions in the **Czech** and **Slovak Republics, Hungary** and **Poland** has been mainly triggered by the collapse in agricultural support levels for livestock, crops and fertilisers resulting in fewer livestock numbers and reduced fertiliser usage in the farm sector following the

Figure 1.7.2. **Ammonia emissions from agriculture**



	Average		Change		Share in total NH_3 emissions
	1990-92	2001-03	1990-92 to 2001-03		2001-03
	'000 tonnes		'000 tonnes	%	%
Korea[1]	143	181	38	27	n.a.
Spain	317	383	67	21	93
United States[2]	3 421	3 945	524	15	88
Portugal	45	51	6	13	78
Canada[3]	468	482	14	3	80
Ireland	115	117	3	2	98
OECD[4]	**8 138**	**8 253**	**115**	**1**	**92**
Norway	20	20	0	0	89
France	744	742	–2	0	97
Greece[5]	76	72	–4	–5	99
EU15	**3 332**	**3 083**	**–249**	**–7**	**94**
United Kingdom	302	277	–25	–8	89
Italy	454	411	–43	–9	94
Luxembourg	6	5	–1	–10	71
Germany	645	580	–66	–10	95
Switzerland[6]	65	57	–8	–12	96
Finland[7]	37	32	–5	–13	97
Austria	75	64	–11	–15	99
Sweden[8]	57	48	–9	–16	84
Denmark[9]	129	103	–26	–20	98
Belgium	95	74	–21	–22	93
Poland[10]	407	317	–90	–22	97
Hungary	98	65	–34	–34	98
Slovak Republic	52	30	–23	–44	96
Czech Republic[11]	131	73	–58	–44	95
Netherlands[12]	236	123	–113	–48	90
Australia[13]	n.a.	61	n.a.	n.a.	n.a.
Japan[14]	n.a.	289	n.a.	n.a.	n.a.

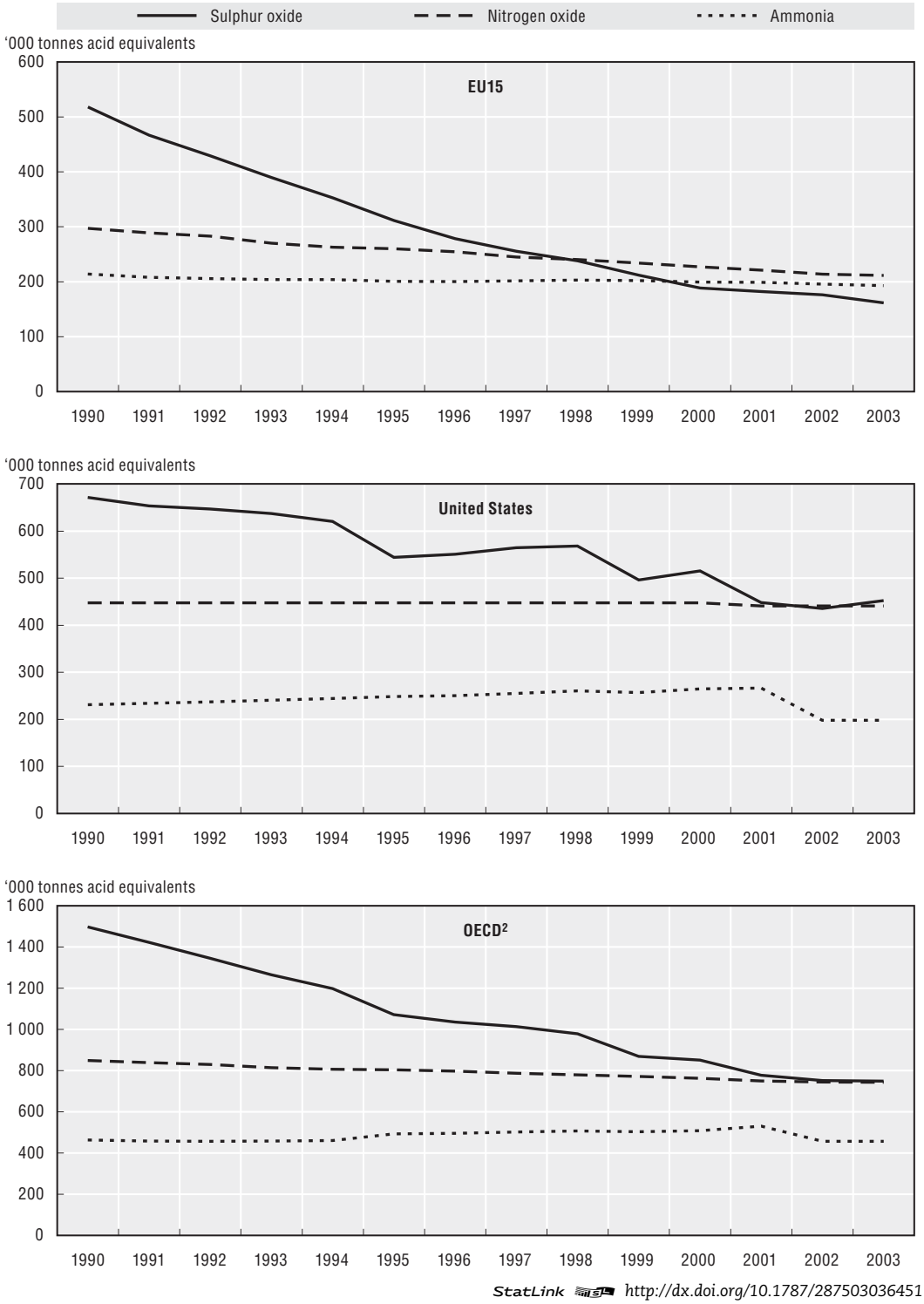
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n.a.: Not available.
1. Data for the periods 1990-92 and 2001-03 refer to the years 1990 and 1998, respectively.
2. Data for the period 2001-03 refer to the year 2000.
3. Data for the periods 1990-92 and 2001-03 refer to the years 1990 and 1995, respectively.
4. OECD excludes: Australia, Iceland, Japan, Mexico, New Zealand and Turkey.
5. Data for the period 2001-03 refer to the year 2001.
6. The period 2001-03 refers to the years 2000-02.
7. Data for the period 1990-92 refer to the year 1990.
8. The period 1990-92 refers to the year 1995.
9. Data for the period 2001-03 refer to the year 2001.
10. Data for the period 2001-03 refer to the year 2001.
11. Data for the period 2001-03 refer to the year 2001.
12. The period 1990-92 refers to the year 1990.
13. Data for the period 2001-03 refer to the year 2000.
14. Data for the period 2001-03 refer to the year 1997.

Source: EMEP (2006); Agriculture and Agri-Food Canada (1998); national data for Italy, Spain, the Netherlands, Norway, Sweden and Switzerland.

transition to a market economy. However, since these countries move towards EU membership, agricultural production has expanded and consequently NH_3 emissions are also beginning to slowly rise (Figure 1.7.4), although the **Czech Republic** has widespread adoption of nutrient management plans that should help toward limiting ammonia emissions (Section 1.9).

Figure 1.7.3. **Emissions of acidifying airborne pollutants**[1] **for the EU15, US and OECD**



StatLink http://dx.doi.org/10.1787/287503036451

1. Includes emissions for all economic activities, including agriculture.
2. OECD excludes: Australia, Iceland, Japan, Korea, Mexico, New Zealand and Turkey.

Source: EMEP (2006).

Table 1.7.1. **Total OECD[1] emissions of acidifying pollutants**

	Average	Share of total	Average	Share of total	Change	
	1990-92[2]		2001-03[3]		1990-92 to 2001-03	
	'000 tonnes acid equivalents[4]	%	'000 tonnes acid equivalents[4]	%	'000 tonnes acid equivalents[4]	%
Sulphur dioxide (SO_2)	1 423	52	759	38	–664	–47
Nitrogen oxides (NO_x)	839	31	746	38	–93	–11
Ammonia (NH_3)	460	17	482	24	22	5
Total	**2 722**	**100**	**1 986**	**100**	**–735**	**–53**

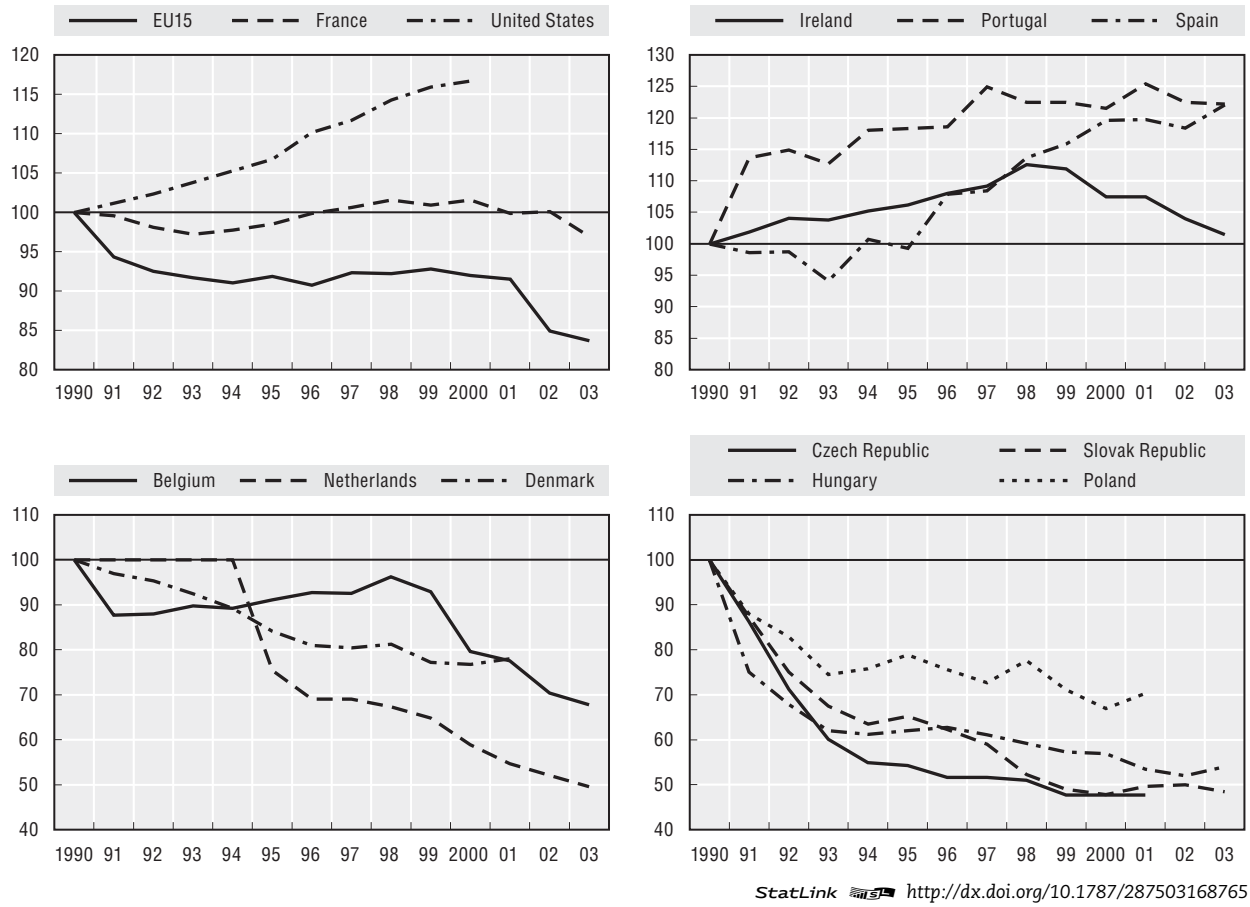
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1. OECD total excludes: Australia, Iceland, Japan, Korea, Mexico, New Zealand and Turkey.
2. 1990-92 average includes following OECD estimate: Data for SO_2 cover Luxembourg: 1991 and 1992. Data for NH_3 cover Canada: 1991 to 1994.
3. 2001-03 average includes following OECD estimate: Data for SO_2 cover Turkey: 2001 and 2002. Data for NH_3 cover Luxembourg: 2001, Greece: 2000 to 2003.
4. The following weighting factors are used to combine emissions in terms of their potential acidifying effect Acid equivalent/g: SO_2 = 1/32, NO_x = 1/46 and NH_3 = 1/17.

Source: EMEP (2006); national data for Netherlands, Spain, Sweden and Switzerland.

Figure 1.7.4. **Agricultural ammonia emission trends for selected OECD countries**

1990 = 100



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Source: EMEP (2006).

The **Netherlands** has achieved a nearly 50% reduction in agricultural NH_3 emissions and **Belgium**, and **Denmark** have also achieved cuts of around 20% (Figure 1.7.4). This has partly been associated with the introduction of nitrogen surplus reduction measures, using a range of policy instruments (*e.g.* taxes on nutrient surpluses, regulations on the storage and spreading of manure, payments for manure storage, etc. (see OECD 2003a and OECD 2004b). These countries all have a high and rising share of the agricultural area and farms under some form of nutrient management plans (Section 1.9).

National trends in agricultural NH_3 emissions mask important regional variations within countries. For example, emissions are highest in Northern **Italy** because of the more intense use of fertilisers in the region, and in **France**, Brittany has the highest emission levels because of the concentration of intensive livestock production in the region (European Commission, 1999). Also ammonia emissions and acidification of soils and acidifying precipitation shows considerable regional variation across the **United States** (Lehmann *et al.*, 2005).

In terms of progress towards achieving the emission targets set for 2010 under the *Gothenburg Protocol*, a varied picture exists. By 2001-2003 many countries had reduced their emissions to meet their target levels under the Protocol (Table 1.7.2). But some countries will need to achieve further emission reductions to reach their targets by 2010, especially **Belgium, Denmark, Finland, Germany, Italy**, the **Netherlands, Spain** and the **United Kingdom** with their 2001-03 emission levels more than 5% above the 2010 LRTAP emission targets, but most notably **Denmark** with emissions nearly 50% above the 2010 target (Table 1.7.2). However, all these countries are encouraging widespread adoption of farm nutrient management practices (Section 1.9) and implementing programmes that seek to reduce ammonia emissions, although in **Italy, Spain** and the **United Kingdom** the share of farms that adopted nutrient plans is low (Chapter 3).

Agricultural NH_3 emissions mainly derive from livestock (manure and slurry) and the application of inorganic fertilisers to crops, and to a much lesser extent decaying crop residues (Figure 1.7.5). For many OECD countries over 90% of total NH_3 emissions are derived from livestock. But for a few countries (**Korea, Japan** and **Poland**) the share of emissions from fertiliser use is over 20% (Figure 1.7.5), reflecting the greater importance of the crop sector in these countries relative to other OECD countries.

Because NH_3 is highly reactive, high concentrations (enough to cause odours and significant nitrogen deposition) usually occur close (*i.e.* less than 2 km) to the emission source (AAFC, 1998). In terms of the deposition of NH_3 while around 20% of emissions are deposited close to the source, the rest can travel long distances through the atmosphere (Hartung, 1999). For example, about 30% of NH_3 emissions in **Germany** are transported to other countries, although a substantial quantity of emissions are also received from other countries (Hartung, 1999), while around 50% of ammonia emissions in **Ireland** are deposited outside the country (EPA, 2000).

In decreasing order of sensitivity to excess NH_3 emissions are: native terrestrial and aquatic habitats; forests; and agricultural crops. But the cumulative impacts on ecosystems in the presence of other acidifying pollutants is poorly understood (Krupa, 2003). There is evidence of adverse impacts from NH_3 emissions on heather bogs in the **Netherlands** and **Central Europe**, and for Eastern regions of the **United States** (Lehmann *et al.*, 2005; Chapter 3). In **New Zealand**, while data on ammonia emissions from agriculture are limited, available information suggests that the critical threshold level for damage to ecosystems from NH_3 emissions is unlikely to be exceeded (Stevenson *et al.*, 2000).

Table 1.7.2. **Ammonia emission targets to 2010 under the Convention on Long-range Transboundary Air Pollution**[1]

	Total ammonia emission levels	Total ammonia emissions	Share of agriculture emissions in total emissions	Total emission ceilings	Change in total emission reductions	Total emissions for 2001-03 as a share of the 2010 emission ceilings[3]
	1990 (base year)	2001-03	2001-03[2]	2010	1990 to 2001-03	
	'000 tonnes		%	'000 tonnes	%	
Austria	69	65	99	66	–6	98
Belgium	107	80	93	74	–25	108
Czech Republic	156	77	95	101	–51	76
Denmark	133	105	98	69	–21	152
Finland	38	33	97	31	–13	107
France	787	768	97	780	–2	98
Germany	736	608	95	550	–17	111
Greece	79	73	99	73	–8	100
Hungary	124	66	98	90	–47	73
Ireland[4]	112	119	98	116	6	103
Italy[5]	464	437	94	419	–6	104
Luxembourg	7	7	71	7	3	103
Netherlands	249	136	90	128	–45	107
Norway	20	23	89	23	12	99
Poland	508	326	97	468	–36	70
Portugal	55	65	78	108 (90)[6]	19	60
Slovak Republic	63	31	96	39	–51	79
Spain	339	411	93	353	21	116
Sweden[7]	64	57	84	57	–11	99
Switzerland[8]	68	59	96	63	–13	94
United Kingdom	370	311	89	297	–16	105
EU15	**3 601**	**3 275**	**94**	**3 128**	**–9**	**105**

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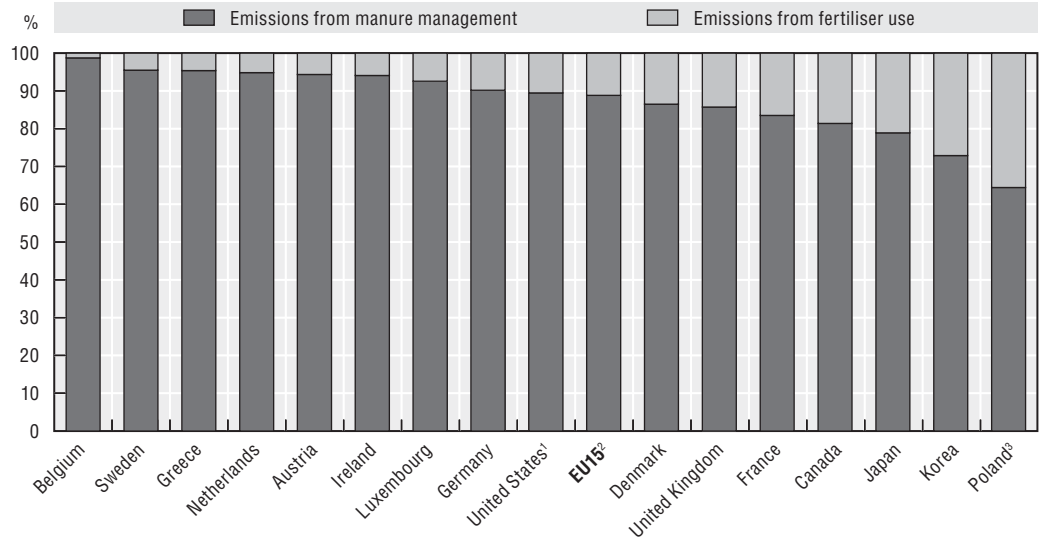
1. The following countries are not signatories to the LRTAP: Australia, Iceland, Korea, Japan, Mexico and New Zealand.
2. See notes, Figure 1.7.2, concerning national averages used for 2001-03.
3. This column shows, for each respective country, the extent to which emissions in 2001-03 were below the emission ceilings for 2010 (*e.g.* Czech Republic) or exceed the emission ceiling (*e.g.* Belgium), by dividing the total emission ceiling for 2010 by the total emissions for 2001-03.
4. In 2004 total ammonia emissions were 14 000 tonnes so the emissions ceiling for 2010 has already been achieved.
5. In 2005 total ammonia emissions were 413 000 tonnes so the emissions ceiling for 2010 has already been achieved.
6. The figure in brackets for Portugal refers to the emission ceiling under the EU Directive on National Emission Ceilings for Certain Atmospheric Pollutants, October 2001 (European Communities, 2001).
7. Sweden: national data for the period 1990-92 refer to the year 1995.
8. National data, the period 2001-03 refers to the years 2000-02.

Source: EMEP (2006); UNECE (2000); national data for Italy, Netherlands, Norway, Spain, Sweden and Switzerland.

With the overall reduction of acidifying emissions in most **West European** OECD countries, including agricultural NH_3 emissions, the European Environment Agency (EEA, 2003) estimates that more than 90% of the ecosystems in Europe are protected against further soil acidification (*i.e.* acidifying deposition is lower than the critical thresholds for these ecosystems). But protection against eutrophication is below 50% (*i.e.* eutrophication is often higher than the critical thresholds for these ecosystems). Even so, the EEA report reveals considerable regional variation in terms of ecosystem protection.

Figure 1.7.5. **Share of the main sources of agricultural ammonia emissions in OECD countries**

Mid-1990s



StatLink http://dx.doi.org/10.1787/287544143084

1. The value for the United States is an OECD estimate from Battye *et al.* (1994).
2. EU15 excludes: Finland, Italy, Portugal, and Spain.
3. For Poland, fertiliser use includes plant residues.

Source: Agriculture and Agri-Food Canada (1998) (for Canada); Battye *et al.* (1994) and OECD estimate (for the United States); European Commission (1999); IMUZ (1999) (for Poland); Lee *et al.* (2002) (for Korea); Murano and Oishi (2000) (for Japan).

1.7.2. Methyl bromide use and ozone depletion

Indicator definition:

- Agricultural methyl bromide use expressed in tonnes of ozone depletion potential.

Concepts and interpretation

Methyl bromide is a fumigant that has been used for more than 50 years in the agri-food sector. It is used to control soil insects, diseases, nematodes and mites in open fields and greenhouses and for pests associated with the storage of food commodities, such as grains. This fumigant has also been used for plant quarantine and pre-shipment protection (UNEP, 2002; USDA, 2000).

While methyl bromide has the advantage of being a low cost fumigant that affects a broad spectrum of pests, it is harmful to human health and soil biodiversity because of its high toxicity. But methyl bromide is an ozone-depleting substance that is more destructive to the ozone layer than many other ozone depleting substances. Ozone depletion hinders the activities of stratosphere ozone layers which prevent harmful ultraviolet (UV-B) rays from reaching the earth, which can cause damage to crop production, forest growth, and human and animal health (IISD, 2004; UNEP, 2002; NOAA, 2001).

The Parties to the *Montreal Protocol on Substances that Deplete the Ozone Layer* agreed in 1997 to a global phase-out schedule for methyl bromide. Under the schedule, developed countries had to reduce methyl bromide use by 25% by 1999, 50% by 2001, 70% by 2003 and 100% by 2005,

compared to 1991 levels. Developing countries (*i.e.* Article 5 member countries under the *Montreal Protocol*), which have contributed less to ozone depletion, started a freeze on use in 2002 at average 1995-98 levels, and need to achieve a 20% reduction by 2005 and 100% by 2015 (UNEP, 2004a). Among OECD countries, **Korea**, **Mexico** and **Turkey** are included under Article 5 of the *Montreal Protocol*.

Methyl bromide use data are collected by the Parties to the *Montreal Protocol*, and reported to the Ozone Secretariat, which is hosted by the United Nations Environment Programme (UNEP). Parties report production, import and export quantities in metric tonnes and the Secretariat calculates the weighted consumption using each substance's ozone-depleting potential (ODP) which is a relative index indicating the extent to which a chemical product may cause ozone depletion (UNEP, 2003; UNEP 2004b). The ODP coefficient of methyl bromide is 0.6, and ODP tonnes are calculated as follows:

$$\text{Methyl bromide ozone depleting potential (ODP tonnes)} = \text{Methyl bromide use (tonnes)} \times \text{Ozone Depletion Potential Coefficient}$$

The data of methyl bromide use for the **EU15** member states were reported to the UNEP as aggregated data for the EU15 in accordance with the *Montreal Protocol*. It should be noted that methyl bromide use for the purpose of quarantine and pre-shipment is exempt from the phase-out programme and the use data for these purposes are not reported to the UNEP, and hence, excluded from the OECD database. Thus, for those countries reporting zero use of methyl bromide by primary agriculture in this section, they could be using the pesticide in the agro-food sector, for quarantine and pre-shipment use.

As an environmental ***driving force***, the methyl bromide use indicator links to the ***state*** (and changes in) of the ozone layer. OECD countries are obliged to ***respond*** in eliminating methyl bromide use to the schedule agreed under the *Montreal Protocol*.

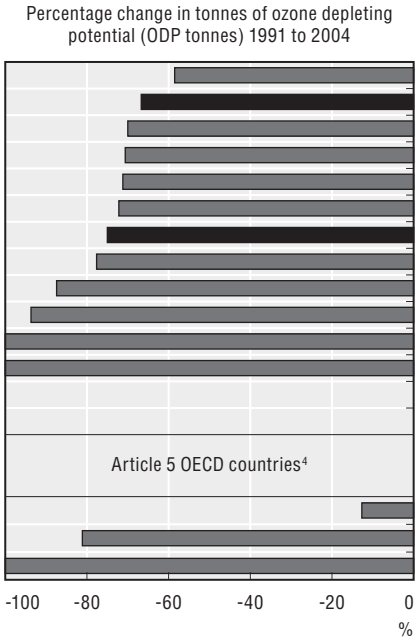
Recent trends

All OECD countries achieved the reduction level targets for methyl bromide specified under the *Montreal Protocol* up to 2003 (Figure 1.7.6; Table 1.7.3). But in 2004 there was a nearly 30% rise in the overall OECD methyl bromide use compared to 2003, largely accounted for by greater use in the **United States**, and, to a lesser extent, in **Australia** and **Japan**. The increase of methyl bromide use in these countries would suggest that there are still technical problems to replace methyl bromide with other alternatives, and that a complete phase-out of methyl bromide in 2005 will require a substantial effort. The **Czech** and **Slovak Republics, Korea** and **Switzerland**, however, have already achieved a complete phase-out of controlled methyl bromide use, while for **Iceland** methyl bromide was not reported to be used by primary agriculture between 1990 and 2004.

While world use of total ODP products declined by over 80% during the period 1990 to 2004, the reduction in methyl bromide was only 55%, reflecting the more rapid reduction in ODP use by non-agricultural users. But the share of OECD methyl bromide use in world total ODP use was only around 8% (Figure 1.7.6). Moreover, OECD countries' share of world total methyl bromide use declined from over 80% in 1991 to 60% in 2004, which stemmed from a reduction in OECD methyl bromide use of nearly 70% (excluding Article 5 countries) over this period (Figure 1.7.6; UNEP, 2004b).

For example, in California in the **United States**, and the southern parts of the **EU15** (*e.g.* **Italy**) soil fumigation treatment, especially for horticultural crops, accounts for about three-quarters of global methyl bromide use (Minuto, 2003; USDA, 2000). In addition, methyl bromide is used for the storage of durable commodities (*e.g.* grains and timber) and perishable

Figure 1.7.6. **Methyl bromide use**



	Tonnes of ozone depletion potential (ODP tonnes) from methyl bromide use				% change
	1991[1]	2002	2003	2004	1991 to 2004
United States	15 317	3 051	4 053	6 353	–59
OECD[2]	**31 305**	**9 353**	**8 066**	**10 417**	**–67**
Poland[3]	120	53	36	n.a.	–70
Australia	422	194	109	123	–71
Canada	120	58	35	35	–71
Japan	3 664	1 770	858	1 019	–72
EU15	**11 530**	**4 184**	**2 953**	**2 873**	**–75**
Norway	6	2	1	1	–78
New Zealand	81	26	13	10	–87
Hungary	32	16	10	2	–94
Czech Republic[3]	6	0	0	n.a.	–100
Slovak Republic[3]	6	0	0	n.a.	–100
Iceland	0	0	0	0	0
Switzerland	0	0	0	0	0
	Average 1995-98[1]	2002	2003	2004	% change 1995-98 to 2004
Mexico	1 131	1 067	968	968	–14
Turkey	480	281	185	91	–81
Korea	30	0	0	0	–100
	1991	2002	2003	2004	% change 1991-2004
World use of ODP products (tonnes)	894 193	162 659	171 086	125 947	–86
World total methyl bromide use (ODP tonnes)	38 651	18 161	15 803	17 386	–55
Share of OECD methyl bromide use in total ODP use (%)	4	6	5	8	
Share of OECD methyl bromide use in world total methyl bromide use (%)	81	52	51	60	

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1. 1991 base period for non-Article 5 countries under the *Montreal Protocol* and 1995-98 for Article 5 countries.
2. OECD excludes Korea, Mexico and Turkey.
3. Data for 2004 are not available. Change from 1990 to 2004 refers to change from 1990 to 2003.
4. Article 5 countries under the *Montreal Protocol*.

Source: UNEP (2006); national data for Hungary (2004 data only), New Zealand and Switzerland.

commodities (*e.g.* fresh fruit and vegetables, cut-flowers), and the disinfestations of structures (*e.g.* buildings, ships and aircraft) (Figure 1.7.7). However, the shares of these latter uses have changed little since 1994 (UNEP, 2002).

Reductions in methyl bromide use have been achieved by a combination of government regulations and changes in the market, as well as pressure from non-governmental organisations and the activities of private companies. Moreover, some countries have adopted a more stringent phase-out schedule than required under the *Montreal Protocol* (UNEP, 2002; Batchelor, 2002), including efforts to develop alternatives (Methyl Bromide Alternatives Outreach, 2003; Department of Primary Industries 2004; USDA, 2003a).

For the three OECD countries – **Korea, Mexico** and **Turkey** – covered under Article 5 of the *Montreal Protocol*, the trends in methyl bromide use have also decreased. While **Mexico** increased its use of methyl bromide more than 10 times from 1991 to 1994, this was followed by a 14% reduction from the 1995-98 baseline to 2004, which met the target of zero increase by 2002 (Figure 1.7.6 and Table 1.7.3). **Turkey** reduced its use of methyl bromide substantially over the period 1995-98 to 2004 and met its 2002 target under the *Montreal*

Table 1.7.3. **Methyl bromide use and progress in meeting the phase-out schedule under the *Montreal Protocol***

Non-Article 5 countries[1]	Consumption baseline 1991 (base year) (ODP tonnes)	Agreed percentage reduction levels from 1991 base year				
		1999	2001	2003	2004	2005
		25%	50%	70%	[3]	100%
		Actual percentage reduction levels from 1991 base year				
Australia	422	28	54	74	71	–
Canada	120	38	57	71	71	–
Czech Republic	6	67	100	100	n.a.	–
Hungary	32	25	50	70	94	–
Iceland	0	0	0	0	0	–
Japan	3 664	25	53	77	72	–
New Zealand	81	51	87	85	87	–
Norway	6	26	62	79	78	–
Poland	120	55	56	70	n.a.	–
Slovak Republic	6	100	100	100	n.a.	–
Switzerland	0	0	0	0	0	–
United States	15 317	44	58	74	59	–
OECD[2]	**31 305**	**62**	**73**	**84**	**76**	**–**
EU15	**11 530**	**35**	**60**	**74**	**75**	**–**

Article 5 countries[1]	Consumption baseline average 1995-98 level (ODP tonnes)	Agreed percentage reduction levels from 1995-98 level			
		2002	2004	2005	2015
		Freeze	[2]	20%	100%
		Actual percentage reduction levels from 1995-98 base year			
Korea	30	100	100	–	–
Mexico	1 131	6	13	–	–
Turkey	480	41	81	–	–

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1. 1981 base period for non-Article 5 countries under the *Montreal Protocol* and 1995-98 for Article 5 countries.
2. OECD excludes Korea, Mexico and Turkey.
3. No percentage reduction is stipulated for 2004.

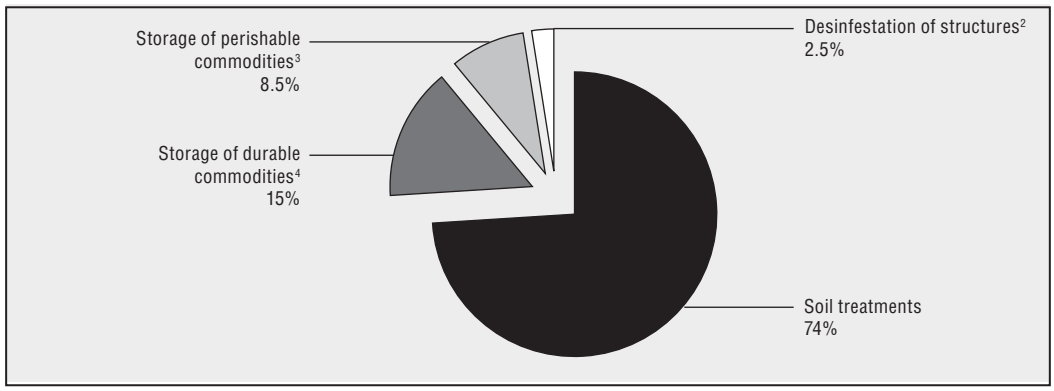
Source: OECD Secretariat, based on UNEP (2006).

Protocol (Figure 1.7.6 and Table 1.7.3). The reduction in Turkey is partly due to the assistance under the Multilateral Fund for the Implementation of the *Montreal Protocol*, jointly planned by the United Nations Development Programme (UNDP), the UNEP, the United Nations Industrial Development Organisation (UNIDO) and the World Bank (Multilateral Fund for the Implementation of the *Montreal Protocol*, 2003). **Korea** had already phased out its use of controlled methyl bromide by the early 1990s (Chapter 3).

For many OECD countries, the phase-out schedule for methyl bromide has posed a technical challenge in terms of finding alternatives, in particular, its use in the horticultural sector. In view of these technical difficulties, the *Montreal Protocol* allows the Parties to apply for ***Critical Use Exemptions*** (CUEs) when there are no feasible alternatives, in addition to the existing exemption for use in quarantine and pre-shipment purposes. The CUEs are intended to give farmers, fumigators and other users of methyl bromide additional time to develop substitutes (UNEP, 2004c). In November 2004, the Parties to the *Montreal Protocol* agreed CUEs for 2005 (UNEP, 2004d) (Table 1.7.4). The share of total CUEs in the 1991 base period values varies between countries, but in most cases it is was over 20% in 2005, except for **Japan** and **New Zealand**, although data are not available for individual **EU15** member states (Table 1.7.4).

Figure 1.7.7. **Global methyl bromide use by major sectors**

2000 estimate[1]



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1. Includes methyl bromide use for quarantine and pre-shipment purposes, which is excluded from the *Montreal Protocol*.
2. Disinfestation of structures includes buildings, ships and aircraft.
3. Storage of perishable commodities includes fresh fruit and vegetables, cut-flowers, some fresh root and bulbs, propagation material and ornamental plants.
4. Storage of durable commodities including, grains, rice straw and timber, etc.

Source: UNEP (2002).

Table 1.7.4. **Critical Use Exemptions (CUEs) for methyl bromide agreed under the *Montreal Protocol* for 2005**

	CUEs agreed	Methyl bromide use	2005 CUEs total compared to 1991
	2005[1]	1991	
	ODP tonnes		%
Australia	88	422	21
Belgium	36	n.a.	n.a.
Canada	37	120	31
France	285	n.a.	n.a.
Germany	27	n.a.	n.a.
Greece	136	n.a.	n.a.
Italy	1 379	n.a.	n.a.
Japan	449	3 664	12
Netherlands	0	n.a.	n.a.
New Zealand	24	81	16
Poland	26	120	22
Portugal	30	n.a.	n.a.
Spain	635	n.a.	n.a.
Switzerland[2]	5	0	n.a.
United Kingdom	81	n.a.	n.a.
United States	4 962	15 317	32
OECD	**8 201**	**31 305**	**26**
EU15	**2 609**	**11 530**	**23**

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n.a.: Not available.

1. Critical use exemptions of methyl bromide use have been granted to the Parties under the *Montreal Protocol*.
2. This only applies to use by the agro-food industry and not to primary agriculture.

Source: OECD Secretariat, based on UNEP (2006).

Granting CUEs may impede the effectiveness of the phase out schedule under the *Montreal Protocol* and act as a disincentive for CUE countries to seek alternatives (IISD, 2004; USDA, 2003b). In addition, some OECD countries have successfully eliminated methyl bromide use by primary agriculture (*e.g.* the **Czech and Slovak Republics, Iceland, Korea** and **Switzerland**) or have never applied for CUEs (*e.g.* **Hungary** and **Norway**) in agriculture.

1.7.3. Greenhouse gas emissions and climate change

Indicator definition:

- Gross total agricultural greenhouse gas emissions (carbon dioxide, methane and nitrous oxide) and their share in total greenhouse gas emissions.

Concepts and interpretation

Agriculture's link to greenhouse gas (GHG) emissions and climate change is complex. While the sector is a contributor of GHGs to the atmosphere, some components of agricultural production systems, (*i.e.* soils) can act as carbon sinks depending on how they are managed (Box 1.7.1). Certain agricultural biomass feedstocks can provide a neutral carbon source of renewable energy (OECD, 2004b). Moreover, while farming is a source of greenhouse gases, principally methane (CH_4) and nitrous oxide (N_2O), which are part of the primary driving force behind climate change, equally climate change may also impact on farm production (IPCC, 2001; USDA, 2003c). Impacts and adaptation to climate change may cause shifts in crop types and cropping patterns in many OECD countries, but this issue is not covered in the Report.

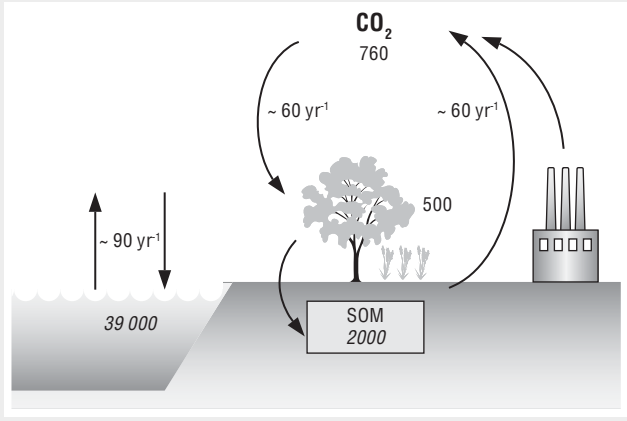
Inventories of the United Nations Framework Convention on Climate Change (UNFCCC) are the main source of data on GHG emissions used in this section (UNFCCC, 2005). These provide a dataset in accordance with the methodology of the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories. The UNFCCC data are comparable as they cover most OECD countries, except **Korea** and **Mexico**, while for **Turkey** national data are used. Emissions of CH_4 and N_2O are converted to carbon dioxide (CO_2) equivalents using weights (Global Warming Potentials).

Major agricultural sources of CH_4 and N_2O, such as enteric fermentation (a process during livestock digestion, where microbes in the digestive system ferment food consumed by the animal), livestock manure, fertiliser and saturated agricultural soils (*e.g.* wet paddy fields), are covered by the agricultural module of the UNFCCC Inventories, together with data for CO_2 from fossil fuel combustion included in the energy module. However, CO_2 emissions from the upstream and downstream agro-food sectors, such as fertiliser and pesticide manufacturing, energy use, transportation and processing are not included in this analysis because the OECD focus of the GHG indicator is on primary agriculture.

While overall the UNFCCC Inventories provide a robust and internationally comparable dataset, there are a number of limitations. National emission estimates made by individual member countries may vary depending on which factors are included in their own calculations. Agricultural sources of CO_2 emissions are limited to on-farm fossil fuel combustion, and in many countries aggregated with emissions from forestry and fisheries. A number of OECD countries are beginning to monitor carbon sequestration in agricultural soils and report these to the UNFCCC (OECD, 2003b).The UNFCCC inventories will in the future categorise carbon sequestration in agricultural soils separately from soil emissions

Box 1.7.1. **Towards a net agricultural greenhouse gas balance indicator?**

On-going policy debates around the implementation of the *Kyoto Protocol*, have led to a new focus in agricultural research on soil organic matter. This relates to the potential of soil organic matter to sequestrate carbon, as organic carbon (C) is a major component of soil organic matter that consists of the cells of micro-organisms, plant and animal residues. The figure (Janzen, 2003) below outlines the global C cycle including the C pool within soil organic matter (SOM). About 40% of the estimated 2 000 Petagrams of soil organic C is contained within the soils of agro-ecosystems (croplands and grazing lands). It is an enormous pool, containing more C than is contained in the earth's atmosphere (760Pg C) as CO_2.



Efforts to research and regularly monitor the potential of agricultural soils to sequester CO_2 are underway in many OECD countries (Chapter 2; and OECD, 2004b). In **Canada**, for example, a net agricultural greenhouse gas balance has been developed, including an estimate of both agricultural emissions and sequestration in soils (Lefebvre *et al.*, 2005). As these efforts progress across countries, it may be possible to develop an OECD net agricultural GHG emission indicator, to replace the gross GHG emission indicator used in this section, and more accurately reflect the role of farming in the context of GHG emissions and climate change.

in accordance with the new LULUCF (*i.e.* land use, land-use change and forestry) reporting requirement. The UNFCCC also collects data on emissions from land use changes, but these data are not included here as it is not possible to extract data explicit to farm land use change (*i.e.* farm land converted to/from other uses).

Agricultural GHG emissions are linked to indicators of nitrogen balances (Section 1.2), ammonia (Section 1.7.1), energy use (1.4), and soil carbon stocks (Chapter 2), as ***driving forces*** in terms of their consequences (or ***state***) for global warming and impacts on climate change. Most OECD countries are committed to GHG emission targets (from 1990 levels) to be achieved by the 2008-12 timeframe, but there are no specific reduction targets set for methane or nitrous oxide, and only a very few OECD countries have established GHG reduction targets for the agricultural sector (*e.g.* **Ireland**, the **United Kingdom**, EEA, 2005). Agriculture's ***response*** to reducing GHGs has been partly through increasing the production and use of renewable energy, improving energy efficiency and also, by lowering emissions through improved nutrient and soil management practices (Section 1.9).

Recent trends

The OECD gross emissions of agricultural GHGs contributed 8% to total OECD national GHG emissions for the 2002-04 period, and declined by 3% from the *Kyoto Protocol* reference period of 1990-92 to 2002-04 compared to a 8% increase for all sectors of the economy (Figure 1.7.8, Table 1.7.5). While agriculture represents a small share in total GHG emissions for some countries the share (2002-04) was in excess of 15% for **Australia, France, Iceland** and **Ireland**. For **New Zealand** this share was almost 50%, due to the high share of agriculture in GDP and the importance of the livestock sector, although **New Zealand's** contribution to total OECD agricultural GHG emissions was 3% in 2002-04 (Table 1.7.5, Figure 1.7.8).

Together the **EU15** and the **United States** accounted for nearly three-quarters of OECD total GHG emissions in 2002-04, but while the **EU15** emissions declined by 7% (a reduction of nearly 31 million tonnes of GHGs in CO_2 equivalents), they increased by 1% (5 million tonnes CO_2) in the **United States**. The largest percentage increases in agricultural GHG emissions (over 5% during the period 1990 to 2004) occurred in **Australia, Canada, New Zealand, Portugal** and **Spain**, which together saw a growth in agricultural GHG emissions of nearly 26 million tonnes CO_2 and now these countries account together for over 20% of total OECD agricultural GHG emissions (Figures 1.7.8 and 1.7.9). But for the majority of OECD countries, GHG emissions decreased between 1990 and 2004.

For all countries, where total GHG emissions are increasing this is largely being driven by an expansion in livestock production (*i.e.* CH_4 from enteric fermentation and manure) and crop production (*i.e.* N_2O from fertiliser use) (Table 1.7.6, Figure 1.7.10). In **Australia**, however, land clearing, mainly for agricultural use, was estimated to contribute in 2000 to 11% of national total GHG emissions, although this estimate is subject to a high degree of uncertainty, with a similar trend of land clearing occurring in **Mexico** (Chapter 3).

In **Canada** and the **United States** over the period 1990 to 2004 agricultural GHG emissions first grew over the first half of the 1990s and then stabilised, and more recently further increased for Canada but declined for the United States (Figure 1.7.9). In addition, farm soils in the **United States** are estimated to sequester about 4 million tons of carbon annually or about 2% of total US terrestrial carbon sequestration in 2001, while in both the **United States** and **Canada** carbon storage in agricultural soils has risen over the 1990s (Chapter 2).

Table 1.7.5. **Total OECD gross greenhouse gas emissions**[1]

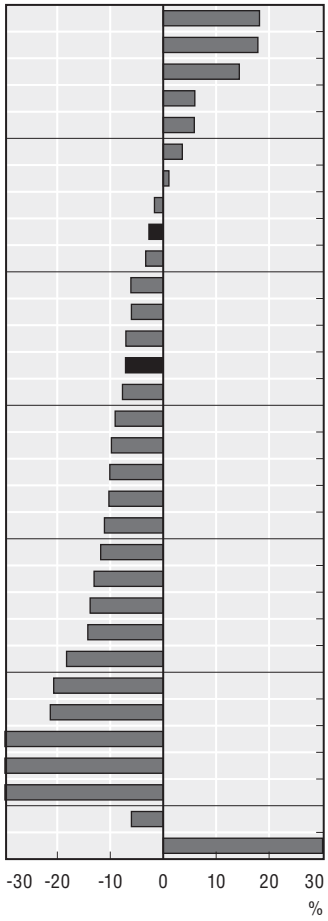
Carbon dioxide equivalent: 1990-92 to 2000-02

Type of GHG	Gross OECD total emissions[2]		Share of each gas in OECD total[2]		Gross emissions from agriculture		Share of each gas in total agricultural emissions		Share of agriculture in OECD total of each gas	
	Million tonnes		%		Million tonnes		%		%	
	1990-92	2000-02	1990-92	2000-02	1990-92	2000-02	1990-92	2000-02	1990-92	2000-02
Carbon dioxide (CO_2)	11 152	12 211	81	83	86	100	7	8	1	1
Methane (CH_4)	1 461	1 256	11	9	556	539	44	42	38	43
Nitrous oxide (N_2O)	966	950	7	6	626	656	49	51	65	69
Others (HFCs, PFCs, SF_6)	160	250	1	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Total	**13 738**	**14 667**	**100**	**100**	**1 268**	**1 296**	**100**	**100**	**9**	**9**

StatLink http://dx.doi.org/10.1787/301461733032

n.a.: Not available.
1. OECD total excludes Korea and Mexico.
2. Data may not add to total due to rounding areas.
Source: UNFCCC (2006).

Figure 1.7.8. **Agricultural gross greenhouse gas emissions**



	Average		Change in agricultural GHG emissions[1]		Change in total GHG emisions	Share of agriculture in national total GHG emissions	Share in total OECD agriculture GHG emissions	Kyoto reduction commitment[7]
	'000 tonnes, CO_2 equivalent		'000 tonnes, CO_2 equivalent	%	%			
	1990-92	2002-04	1990-92 to 2002-04		1990-92 to 2002-04	2002-04	2002-04	2008-12
Spain	39 737	47 003	7 265	18	41	11	4	+15
Canada	44 781	52 823	8 043	18	23	7	5	–6
New Zealand	32 322	36 990	4 668	14	19	49	3	0
Portugal	7 909	8 400	490	6	36	10	1	+27
Australia	90 707	96 081	5 374	6	22	18	8	+8
Poland	27 114	28 099	985	4	–21	7	2	–6
United States	440 855	445 661	4 806	1	14	6	39	–7
Ireland	19 376	19 059	–316	–2	24	28	2	+13
OECD[2]	**1 162 343**	**1 131 881**	**–30 462**	**–3**	**8**	**8**	**100**	. .
Norway	4 468	4 321	–147	–3	10	8	0	+1
Sweden	9 223	8 659	–564	–6	–3	12	1	+4
Luxembourg	486	458	–28	–6	–9	4	0	–28
Italy	41 520	38 591	–2 929	–7	12	7	3	–6.5
EU15	**426 577**	**395 966**	**–30 611**	**–7**	**0**	**9**	**35**	**–8**
France	105 794	97 625	–8 169	–8	–3	17	9	0
Switzerland	6 640	6 037	–603	–9	–3	12	1	–8
Greece	13 309	12 005	–1 304	–10	26	9	1	+25
Belgium	12 874	11 641	–1 233	–10	–1	8	1	–7.5
Iceland	554	497	–57	–10	6	15	0	+10
Germany	72 572	64 506	–8 066	–11	–14	6	6	–21
Austria	9 079	8 004	–1 074	–12	15	9	1	–13
United Kingdom	52 808	45 896	–6 912	–13	–11	7	4	–12.5
Finland	6 654	5 732	–922	–14	12	7	1	0
Japan	32 287	27 676	–4 611	–14	10	2	2	–6
Netherlands	22 391	18 291	–4 100	–18	0	8	2	–6
Turkey	18 930	15 000	–3 930	–21	43	6	1	. .
Denmark	12 846	10 096	–2 750	–21	–3	14	1	–21
Hungary[3]	16 447	10 665	–5 782	–35	–32	13	1	–6
Czech Republic[4]	13 718	8 060	–5 658	–41	–18	6	1	–8
Slovak Republic[4]	6 943	4 004	–2 939	–42	–22	8	0	–8
Korea[5]	4 798	4 527	–271	–6	5	3	. .	. .
Mexico[6]	38 863	55 674	16 811	43	. .	8	. .	. .

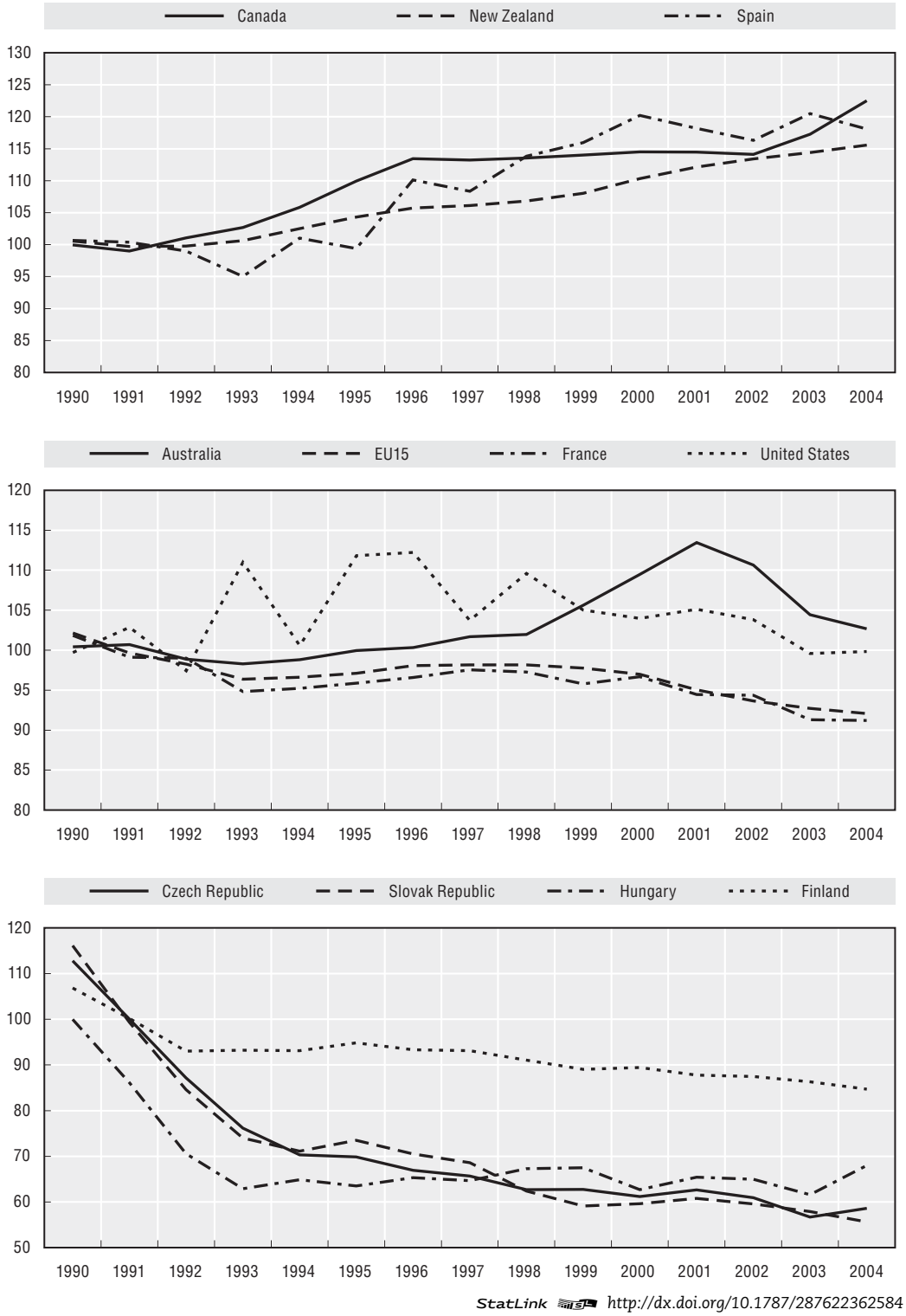
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1. Gross GHG emissions from agriculture include emissions of CH_4, N_2O and CO_2 (fossil fuel combustion only), but exclude CO_2 emissions from soils and agriculture land use change.
2. Excluding Korea and Mexico.
3. Data for the period 1990-92 refer to 1990. The change for Hungary is –35%.
4. The change for the Czech Republic is –41%. The change for the Slovak Republic is –42%.
5. Data for the period 1990-92 and 2000-02 refer to the year 1990 and average 1999-2001. *Source:* Second National Communication of the Republic of Korea under the United Nations Framework Convention on Climate Change.
6. Data for the period 1990-92 and 2000-02 refer to the years 1990 and 1998. The change for Mexico is 43%.
7. Overall, the EU15 has a Kyoto reduction commitment of –8%, but commitments vary across EU member states under the EU Burden Sharing Agreement.

Source: EUROSTAT (2006); national data (for the Slovak Republic); UNFCCC (2006).

Figure 1.7.9. **Gross agricultural greenhouse gas emissions in carbon dioxide equivalent for selected OECD countries**

Average 1990-92 = 100



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Source: EUROSTAT (2006); national data (for the Slovak Republic); UNFCCC (2006).

Table 1.7.6. **Main sources and types of gross greenhouse gas emissions**

1990-92 to 2000-02

	Livestock farming[1]	Crop production[2]	Fuel combustion from agriculture	CO_2	N_2O	CH_4	Total agriculture GHG
				%			
Australia	–2	45	25	25	40	3	11
Austria	–9	–7	39	39	–7	–10	1
Belgium	–3	–19	11	11	–16	–4	–5
Canada	15	18	–19	–19	18	14	15
Czech Republic	–39	2	n.a.	n.a.	1	–40	–13
Denmark	–3	–26	–12	–12	–25	–2	–17
Finland	–14	–16	–11	–11	–17	–11	–14
France	–3	–5	–10	–10	–5	–3	–5
Germany	–13	–9	–16	–16	–10	–12	–12
Greece	1	–4	–4	–4	–4	2	–3
Hungary[3]	–36	–46	n.a.	n.a.	–19	–44	–22
Iceland	–9	–2	n.a.	n.a.	–4	–8	–6
Ireland	4	6	22	22	6	4	6
Italy	–3	–1	11	11	0	–5	0
Japan	–10	–16	–5	–5	–13	–13	–10
Luxembourg	–12	0	–4	–4	0	–12	–2
Netherlands	–21	–2	6	6	–2	–21	–7
New Zealand	10	23	17	17	23	10	14
Norway	0	–4	–7	–7	–4	–1	8
Poland	–18	–3	n.a.	n.a.	48	–41	16
Portugal	–2	–10	15	15	–5	–5	–2
Slovak Republic	–48	–32	n.a.	n.a.	–36	–48	–40
Spain	20	11	34	34	10	22	18
Sweden	–6	–6	–15	–15	–8	–2	–7
Switzerland	–10	–10	8	8	–10	–10	–8
Turkey[4]	–20	13	n.a.	n.a.	2	–19	–19
United Kingdom[5]	–8	–11	–27	–27	–11	–9	–11
United States	3	8	n.a.	n.a.	8	2	6
OECD[6]	**–3**	**3**	**0**	**0**	**4**	**–3**	**1**
EU15	**–5**	**–6**	**1**	**1**	**–6**	**–5**	**–5**

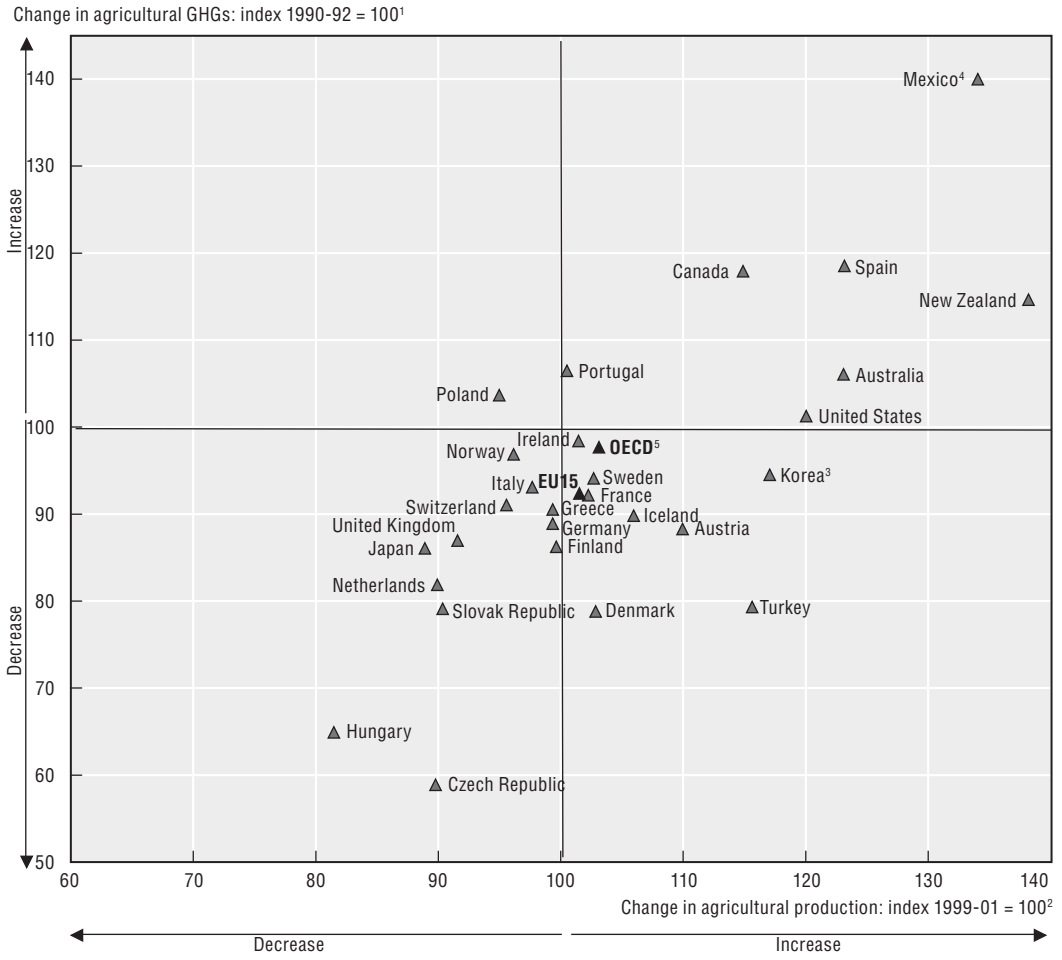
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n.a.: Not available.

1. Livestock farming includes emissions from enteric fermentation and livestock waste.
2. Crop production includes emissions from agricultural soil (mainly fertiliser application) and other crops (mainly rice and residue burning).
3. Data for the period 1990-92 refer to the year 1990.
4. Livestock farming includes only CH_4 emissions from livestock waste, because N_2O emissions from livestock are not available.
5. Crop productions exclude both N_2O and CH_4 emissions from field burning of agricultural residues, because data for 1994-2002 are not available.
6. Excluding Korea and Mexico.

Source: EUROSTAT (2006); national data (for the Slovak Republic and Luxembourg); UNFCCC (2006).

Figure 1.7.10. **Agricultural production and agricultural greenhouse gas emissions**
Change in index 1990-92 to 2002-04



StatLink http://dx.doi.org/10.1787/287624580048

1. See notes to Figure 1.7.8.
2. The Agricultural Production Index is a volume index of total crop and livestock production. The data included in the figure are averages for 2002-04, with 1999-01 as the base period = 100, see Figure 1.7.9, Section 1.1 of this chapter.
3. Data for the period 2001-03 refer to the year 1999-01 for agricultural greenhouse gas emissions.
4. Data for the period 1990-92 and 2001-03 refer to the year 1990 and 1998 for agricultural greenhouse gas emissions.
5. For OECD, Belgium and Luxembourg are not included, because data are not available on the Agricultural Production Index and, for Korea and Mexico, on agricultural greenhouse gases.

Source: EUROSTAT (2006); FAOSTAT (2006); national data (for the Slovak Republic); UNFCCC (2006).

Relating the growth in total agricultural production and agricultural GHG emissions over the period 1990-2004 is shown in Figure 1.7.10. Typically countries where agricultural production has increased (decreased), agricultural GHG emissions have risen (declined). While Figure 1.7.10 can only provide indirect evidence of progress in decoupling agricultural production from changes in agricultural GHG emissions. However, the trends notably for **Denmark** and **Turkey** (reductions in GHG emissions and increases in agricultural production) and, also **Australia, New Zealand** and the **United States** (smaller increases in GHG emissions compared to those in agricultural production), highlight the possibility for countries to reduce growth rates in GHG emissions below the rate of agricultural production growth.

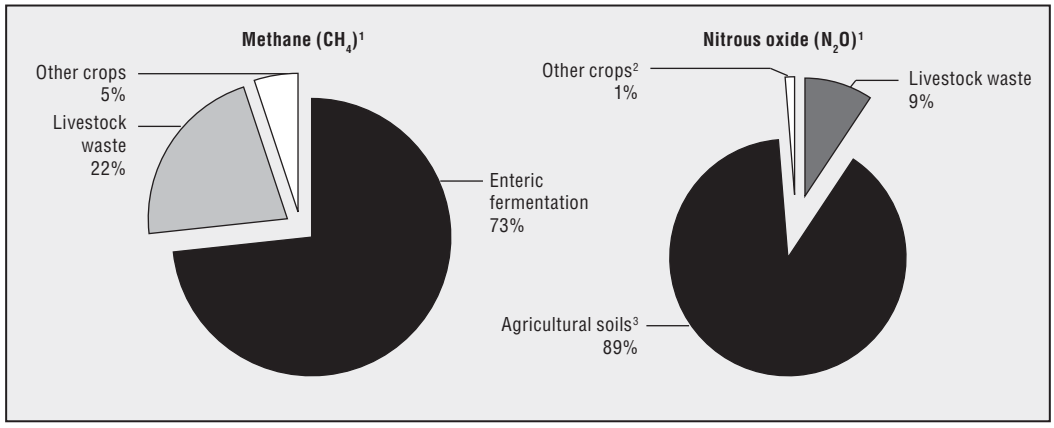
The share of agriculture in total **carbon dioxide** emissions is around 1% which largely originates from fuel combustion linked to the use of farm machinery and in heating livestock and horticultural housing. However, although the share of total agricultural GHG emissions is relatively small in total GHG emissions, it is one of the major sources of methane and nitrous oxide emissions, contributing over 40% and nearly 70% of gross national emissions of these gases respectively (Table 1.7.5).

The major sources of **methane** (CH_4) emissions from agriculture are from livestock enteric fermentation and livestock manure (Figure 1.7.11), although emissions from rice paddy production are important in **Japan** and **Korea**. CH_4 emissions as a share of total agriculture GHG emissions slightly declined over the 1990s (Table 1.7.5), largely attributed to the reduction of GHG emissions from livestock farming (Table 1.7.6). Even so, livestock contributes over 50% of total agricultural GHG emissions in a number of OECD countries (Figure 1.7.12, and OECD, 2003a; 2004b).

For **nitrous oxide** (N_2O), the main source of emissions from agriculture is derived from the application of fertilisers on soils, while manure waste, crop residues and cultivation of organic soils also contribute to these emissions (Figure 1.7.11). Agricultural N_2O emissions increased over the 1990s largely as a result of a 3% growth in GHG emissions from crop production across OECD countries (Table 1.7.6, and OECD, 2005), which is a major source of GHG emissions for some countries (Figure 1.7.12).

Figure 1.7.11. **Main sources of methane and nitrous oxide emissions in OECD agriculture**

2000-02



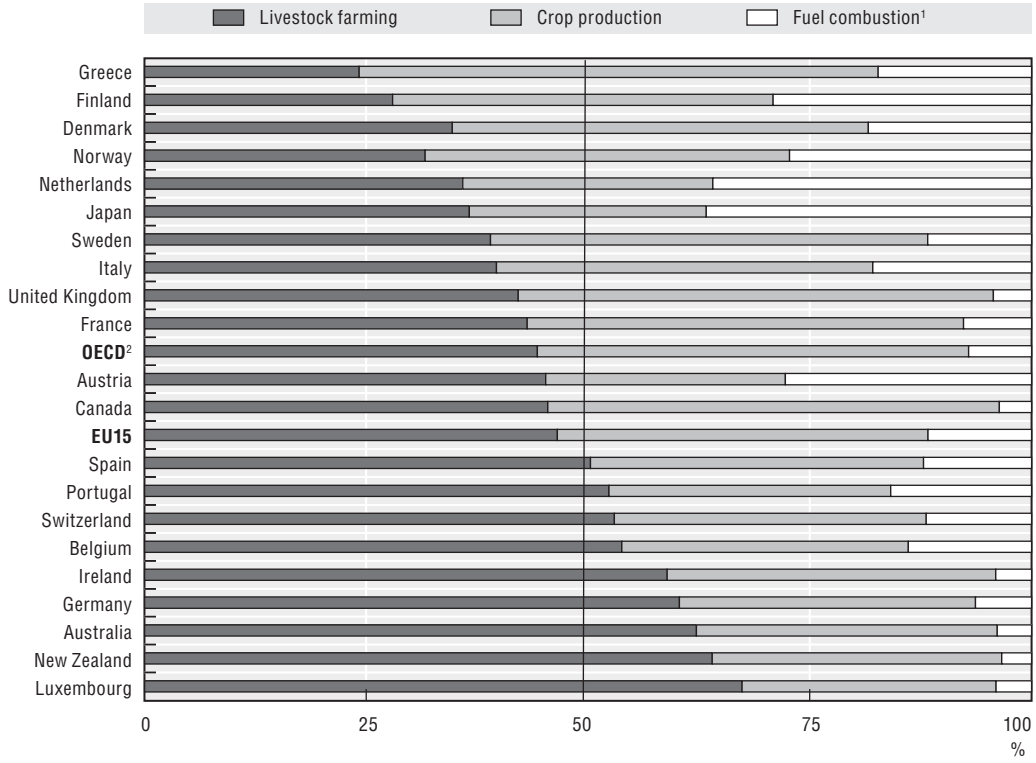
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1. Data may not add to total due to rounding areas.
2. Other crops include grassland, rice and crop residue burning for CH_4 and grassland and crop residue burning for N_2O, respectively.
3. Mainly emissions from the application of fertilisers.

Source: UNFCCC and national data (for the Slovak Republic and Luxembourg).

Figure 1.7.12. **Contribution of main sources in agricultural greenhouse gas emissions**

2000-02



StatLink http://dx.doi.org/10.1787/287706255450

1. Countries for which fuel combustion data are not available are not included, see Table 1.7.6.
2. Excluding the Czech Republic, Hungary, Poland, Iceland, Korea, Mexico, the Slovak Republic, Turkey and the United States.

Source: EUROSTAT (2006); national data; UNFCCC (2006).

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1.8. BIODIVERSITY

KEY TRENDS

Overall OECD trends (1990-2002) suggest an increasing diversity of crop varieties and livestock breeds used in production, but the extent to which this is improving the environmental resilience of agricultural production systems and lowering risks from pathogens and disease is unclear.

Trends in *endangered livestock breed* numbers reveal a mixed picture, increasing in some countries (Austria, Spain) and declining for others (Denmark, Italy). Across livestock categories considered within the endangered and critical risk category, cattle and sheep breeds have the highest numbers of breeds at risk relative to pigs and poultry for most countries in 2002. There are limited data on endangered crops to decipher any OECD wide trends.

Most countries have implemented *conservation programmes* designed to protect and enhance the populations of endangered livestock breeds, and the number of breeds included under these programmes is increasing. Greater efforts are underway to conserve plant genetic resources useful for crop improvement.

Only a few OECD countries produce transgenically modified crops, but they account for two-thirds of the global world planted area of these types of crops. The area sown to these crops has grown rapidly since the mid-1990s, notably in Canada and the United States, dominated by herbicide tolerant crops or crops resistant to certain insects. The development of transgenic crops has raised concerns over the possibility of genetic contamination of traditional landraces and wild relatives, such as maize in Mexico.

In OECD countries agricultural land is a major primary habitat for certain populations of wild species. This is particularly the case for certain species of birds and insects, in particular butterflies. But for flora the situation is variable across countries and land uses, and for mammals farmland is less important as a habitat, although certain species are intrinsically linked to such land (*e.g.* certain rodents and hares).

Farmland bird populations declined over 1991-2004, but the decrease was less pronounced than had occurred over the 1980s, and for some countries populations have been rising since the late 1990s. The main causes of the decline in bird and other terrestrial and aquatic wild species impacted by agriculture are: changes to the habitat quality in agricultural land or its loss to other uses; the use of pesticides and fertilisers; lowering groundwater tables and river flows; and clearance of native vegetation, such as forests.

For nearly all OECD countries there was a net reduction in agricultural land area over the period 1990-92 to 2002-04, with a few exceptions (Belgium, Luxembourg, Mexico, Norway and Turkey). Farmland has been mainly converted to use for forestry and urban development, with much smaller areas converted to wetlands and other land uses. While little quantitative information about the biodiversity implications of converting farmland to forestry is available, the high rates of clearance of native vegetation for agricultural use in some countries (*e.g.* Australia, Mexico) are damaging biodiversity.

While the total areas of ***wetlands converted to farmland*** were only a small share of the total farmed area over the period 1985-89 to 2001-03, there has been a net loss of wetlands converted to agricultural use, although at a declining rate of loss, in Italy, Japan, Korea and Norway. Wetlands are highly valued habitats for biodiversity and their loss is of international significance as recognised through various International Environmental Agreements. For some countries, however, while the conservation and loss of farmed wetland habitats is an important issue, data on the extent of these farmed wetlands are poor.

A major share of agricultural ***semi-natural habitats*** consists of *permanent pasture*, which for most OECD countries has declined (1990-92 to 2002-04), mainly being converted to forestry, although for some countries pasture has also been converted for cultivation of arable and permanent crops (*e.g.* Australia, Mexico). However, for some types of semi-natural agricultural habitats (farm woodland and fallow land) the area has increased or remained stable for a number of countries.

For many OECD countries agriculture accounted for a major share of the harmful impacts affecting the quality of ***Important Bird Areas*** (IBAs) in the late 1990s, through a greater intensification of farming. In some cases, however, the conversion of agricultural land use to non-agricultural uses has reduced the habitat quality of IBAs, especially in marginal extensive farming areas.

Background

The Convention on Biological Diversity (CBD, 2002) defines agricultural biodiversity at levels from genes to ecosystems that are involved or impacted by agricultural production (Box 1.8.1). Agricultural biodiversity is distinct in that it is largely created, maintained, and managed by humans through a range of farming systems from subsistence to those using a range of biotechnologies and extensively modified terrestrial ecosystems. In this regard, agricultural biodiversity stands in contrast to "wild" biodiversity which is most valued *in situ* and as a product of natural evolution.

Box 1.8.1. **Defining agricultural biodiversity**

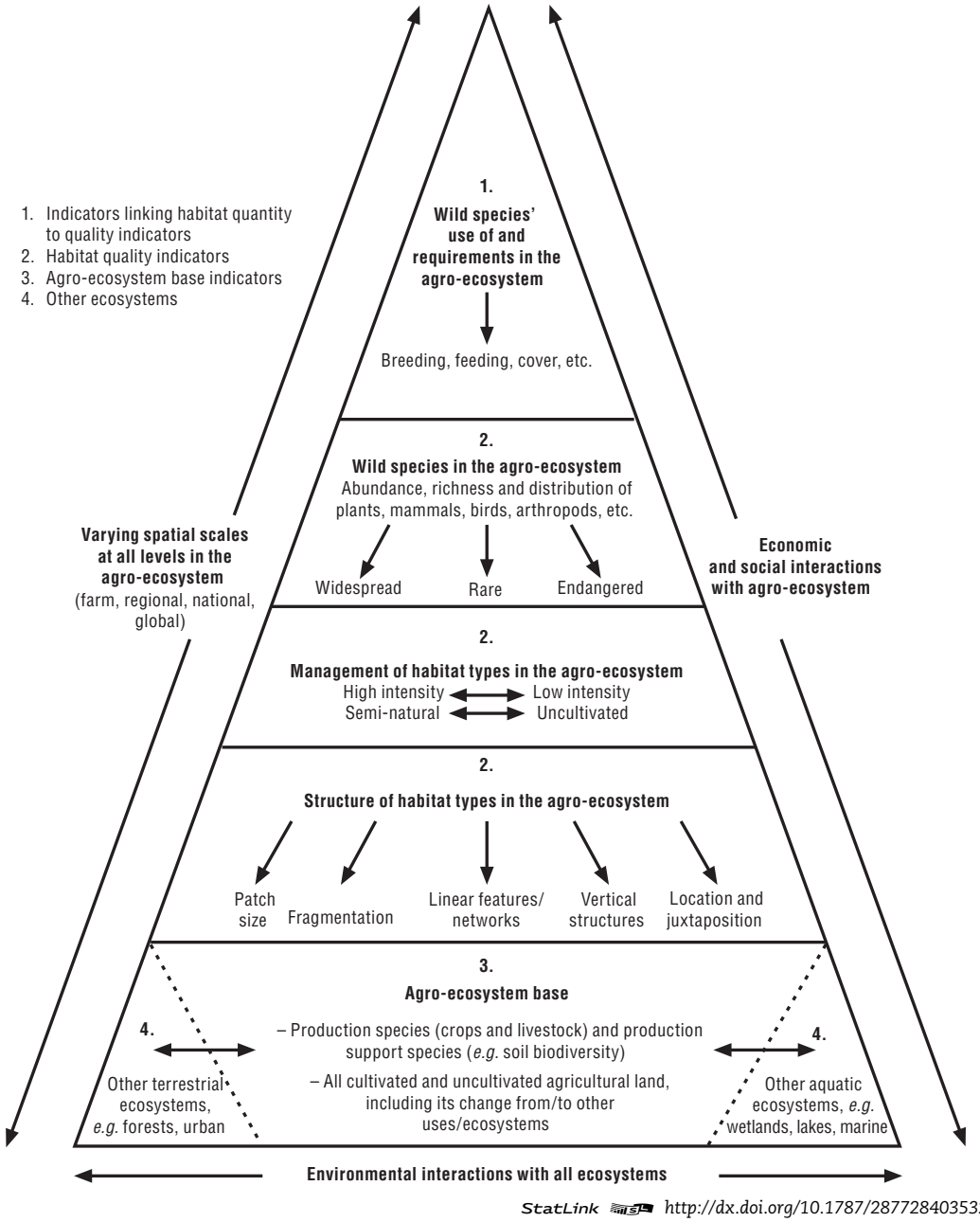
Drawing on the CBD definition of biodiversity, agricultural biodiversity in this report is defined in terms of three levels (OECD, 2001):

1. ***Genetic diversity:*** the number of genes within domesticated plants and livestock species and their wild relatives.
2. ***Species diversity:*** the number and population of wild species (flora and fauna) both dependent on, or impacted by, agricultural activities, including soil biodiversity and effects of non-native species on agriculture and biodiversity.
3. ***Ecosystem diversity:*** populations of domesticated and wild species and their non-living environment (*e.g.* climate), which make up an *agro-ecosystem* and is in contact with other ecosystems (*i.e.* forest, aquatic, steppe, rocky and urban). The agro-ecosystem consists of a variety of habitats limited to an area where the ecological components are quite homogenous and are cultivated, such as extensive pasture or an orchard, or are uncultivated but within a farming system, such as a wetland.

OECD countries employ a variety of policies and approaches to reconcile the need to enhance farm production, drawing on plant and livestock genetic resources, and yet reduce harmful biodiversity impacts, especially on wild species (*e.g.* birds) and habitats (*e.g.* wetlands). To better understand the complexity of agri-biodiversity linkages and with the aim of developing a set of indicators that can capture this complexity, the OECD has developed an Agri-Biodiversity Framework (ABF) (Figure 1.8.1; OECD 2003a).

The ABF recognises three key aspects in agri-biodiversity linkages. First, an agro-ecosystem provides both food and non-food commodities, and environmental services (*e.g.* scientific, recreational, ecological), which operate at varying spatial scales from the field to the global level. Second, the agro-ecosystem consists of plant and animal communities (domesticated crops and livestock, and wild species), which interact with the economic and social aspirations of farming. Third, the agro-ecosystem is linked to other ecosystems, both terrestrial (*e.g.* forests) and aquatic (*e.g.* wetlands), especially in terms of the effects of farming practices on other ecosystems but also the effects of these ecosystems on agriculture.

Figure 1.8.1. **OECD agri-biodiversity indicators framework**



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Source: OECD (2003a).

Within an agro-ecosystem the ABF highlights a hierarchical structure of three layers, from which OECD has developed the indicators in this section. The first layer is the production base of agriculture, in particular, its use of *genetic resources* (plants and livestock). A second layer consists of the structure (*e.g.* field mosaic, linear features) and management (*i.e.* variety of farming practices and systems) of *habitats* within the agro-ecosystem, which impacts on the third and final layer. This layer covers the abundance, richness and distribution of *wild species* either dependent on or impacted by agricultural activities.

1.8.1. Genetic diversity

Indicator definitions:

- Plant varieties registered and certified for marketing for the main crop categories (*i.e.* cereals, oilcrops, pulses and beans, root crops, fruit, vegetables and forage).
- Five dominant crop varieties in total marketed production for selected crops (*i.e.* wheat, barley, maize, oats, rapeseed, field peas and soyabeans).
- Area of land under transgenic crops in total agricultural land.
- Livestock breeds registered and certified for marketing for the main livestock categories (*i.e.* cattle, pigs, poultry, sheep and goats).
- Three dominant livestock breeds in total livestock numbers for the main livestock categories (*i.e.* cattle, pigs, poultry, sheep and goats).
- Livestock (*i.e.* cattle, pigs, poultry and sheep) in endangered and critical risk status categories and under conservation programmes.
- Status of plant and livestock genetic resources under *in situ* and *ex situ* national conservation programmes.

Concepts and interpretation

Genetic resources are the basic building block which enables plants and livestock to provide food and other commodities and is vital for increasing agricultural productivity (Rubenstein, *et al.*, 2005). The loss of varieties of crop plants and livestock breeds and their wild relatives, or genetic erosion, is a key biodiversity issue facing agriculture. The genetic loss of resources can increase social vulnerability to pathogens and increase the risks associated with securing food supplies (Heal *et al.*, 2004). Genetic erosion is due to a number of factors of which perhaps the most significant is the introduction and growing use of modern varieties and breeds followed by land use change. International co-operation on agricultural genetic resource conservation, including by the CBD and FAO, have helped to initiate changes in the way genetic resources are managed. Improved inventories, maintained by organisations like FAO, of traditional and native crop varieties and livestock breeds, assist national conservation programmes to avoid loss of genetic resources in agriculture.

Monitoring and interpreting the extent and changes in agricultural genetic resource (AGR) diversity and genetic erosion is complex, especially in tracking spatial and temporal changes (Rubenstein *et al.*, 2005). The focus of the OECD AGR indicators within the ABF is to:

1. track changes in AGR diversity used for agricultural production;
2. monitor to what extent AGR diversity is endangered or in a critical state of being lost; and
3. provide information on the current status of AGR under national conservation programmes.

Tracking changes in agricultural livestock genetic resources is somewhat more advanced than for crops. This is reflected in the greater progress that has been made in coverage of the FAO's database for livestock genetic diversity compared to crops (Scherf [2000] and the FAO website *www.fao.org/dad-is/*). Indeed, while an indicator is provided on trends in genetic erosion of livestock breeds, this is not possible at present for crops, although some countries are beginning to make progress in this area (Chapter 2).

Interpreting trends in AGR indicators is difficult as comprehensive knowledge about the interactions and potential environmental impacts is not yet available. Moreover, some of the indicators in this section only provide indirect evidence of developments in AGR diversity (*i.e.* area planted to transgenic crops), while others mainly provide qualitative information (*i.e.* the status of AGR under national conservation programmes). Moreover, while the AGR indicators of varieties/breeds registered for marketing and the share in total crop production/livestock numbers are the best indicators currently available they do not indicate genetic distances between varieties/breeds and thus do not indicate the extent of change in genetic diversity. However, efforts to develop more robust indicators of changes in AGR diversity have progressed considerably in many OECD countries (OECD, 2003a).

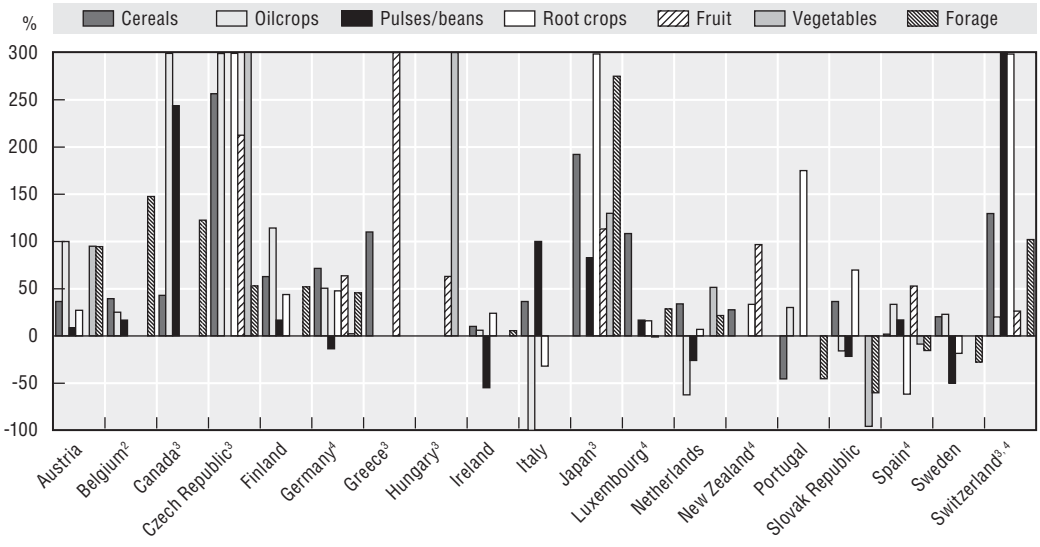
Overall changes in farming practices and systems (Section 1.9) are the key ***driving forces*** that link to the ***state*** of AGR diversity and ***responses*** in terms of national conservation programmes and in terms of areas under agri-biodiversity management plans (Section 1.9). There are also links with AGR and wild species, related to the concerns of modified genetic plants escaping into the "wild".

Recent trends

Agricultural plant genetic resources. Overall OECD trends (1990-2002) suggest that there is ***increasing diversity of crop varieties*** used in production, but the extent to which this is improving the environmental resilience of cropping systems and lowering risks to pathogens and disease remains unclear (Figures 1.8.2, 1.8.3). These trends are supported by other recent

Figure 1.8.2. **Change in the number of plant varieties registered and certified for marketing**[1]

% change 1990 to 2002



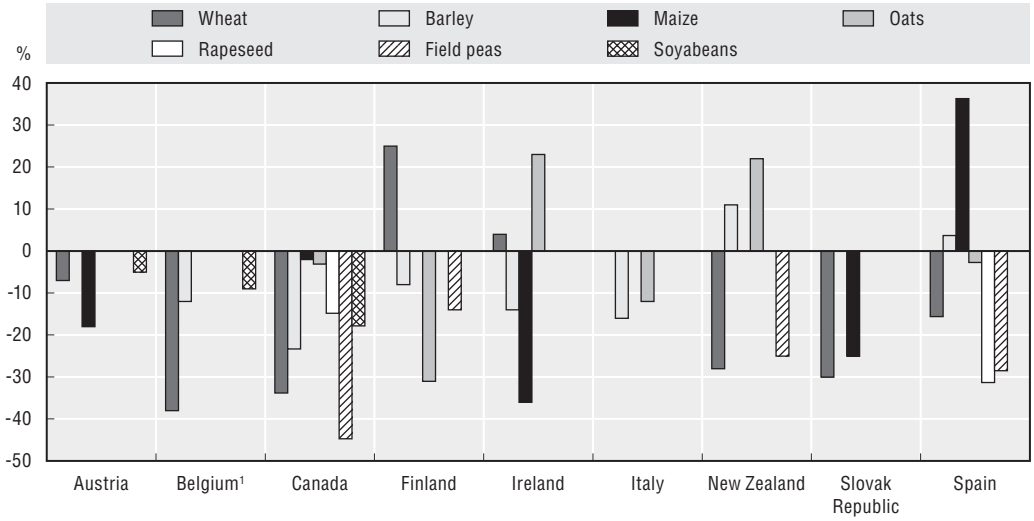
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1. Industrial crop data are not included, because data are not available for many countries.
2. Data for 1990 and 2001 include only Flanders.
3. For Canada, the figure for oilcrops is 633%. For the Czech Republic, the figure for oilcrops is 486%; for root crops, 418%; and for vegetables, 307%. For Greece, the figure for fruit is 337%. For Hungary, the figure for vegetables is 465%. For Japan, the figure for rootcrops is 550%. For Switzerland, the figure for pulses/beans is 350%; and for rootcrops, 368%.
4. Percentages are zero or close to zero per cent for Germany (vegetables), Luxembourg (oilcrops, fruit, vegetables), New Zealand (forage), Spain (cereals), Switzerland (vegetables).

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

Figure 1.8.3. **Change in the share of the one-to-five dominant crop varieties in total marketed crop production**

% change 1990 to 2002



Percentage share of the one to five dominant crop varieties in total marketed crop production: 2002

	Wheat	Barley	Maize	Oats	Rapeseed	Field peas	Soyabeans
Austria	59	. .	37	. .	. .	. .	80
Belgium[1]	27	65	20	. .	100	. .	90
Canada	46	40	25	59	39	52	18
Finland	85	63	. .	50	. .	66	. .
Ireland	72	72	63	71	. .	. .	. .
Italy	. .	51	. .	77	. .	. .	. .
New Zealand	43	66	. .	58	. .	75	. .
Slovak Republic	46	. .	19	. .	. .	. .	. .
Spain	38	50	72	92	48	61	. .

StatLink http://dx.doi.org/10.1787/287780717261

n.a.: Not available.
1. Data for Flanders.
Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

studies, for example, in the **EU15** (EEA, 2005) and **United States** (Rubenstein *et al*., 2005). For only a few crops and countries, have the number of plants registered and certified for marketing declined over the past decade, notably for pulses, oilcrops and root crops, in **Italy**, the **Netherlands, Portugal, Slovak Republic, Spain** and **Sweden** (Figure 1.8.2). Similarly for only a few crops (wheat, maize, and oats) and countries (**Finland, Ireland, New Zealand, Spain**) did the trend in share of the dominant crop varieties in crop production tend to increase and their share in crop production rise above 70% (Figure 1.8.3).

A limited number of OECD countries report commercial production of ***genetically modified crops***, but account for two-thirds of the world global planted area of these types of crops (Table 1.8.1; James, 2005). The area sown to these crops has grown rapidly since the mid-1990s, especially in **Canada** and the **United States**, dominated by herbicide tolerant crops (soybean, maize, canola, and cotton). The development of transgenic crops has raised concerns over the possibility of genetic contamination of traditional species and wild relatives, such as maize in **Mexico** (OECD, 2005). **Mexico** is recognised as a "*Vavilov*" centre, which is an area where crops were first domesticated and have evolved over several thousand years, as is the case for maize (Chapter 3).

Table 1.8.1. **Area of transgenic crops for major producing countries**

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	% share in total agricultural area 2005[1]
	Million hectares										
OECD member countries											
Australia	< 0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.3	< 0.1
Canada	0.1	1.3	2.8	4.0	3.0	3.2	3.5	4.4	5.4	5.8	8.6
France	–	–	< 0.1	< 0.1	< 0.1	–	–	–	–	. .	–
Spain	–	–	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	0.3
Mexico	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1
Portugal	–	–	–	< 0.1	–	–	–	–	–	. .	–
United States	1.5	8.1	20.5	28.7	30.3	35.7	39	42.8	47.6	49.8	12.2
OECD total	**1.6**	**9.5**	**23.5**	**32.8**	**33.5**	**39.1**	**42.6**	**47.3**	**53.4**	**56.1**	**4.4**
Non-OECD countries											
Argentina	0.1	1.4	4.3	6.7	10	11.8	13.5	13.9	16.2	17.1	–
Brazil	–	–	–	–	–	–	–	3.0	5.0	9.4	–
China	–	0	< 0.1	0.3	0.5	1.5	2.1	2.8	3.7	3.3	–
India	–	–	–	–	–	–	< 0.1	0.1	0.5	1.3	–
Paraguay	–	–	–	–	–	–	–	–	1.2	1.8	–
South Africa	–	–	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.5	–
Other countries[2]	–	–	–	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.4	0.5	–
Non member total	**0.1**	**1.4**	**4.3**	**7.1**	**10.7**	**13.5**	**15.9**	**20.2**	**27.5**	**33.9**	**–**
World total	**1.7**	**10.9**	**27.8**	**39.9**	**44.2**	**52.6**	**58.5**	**67.5**	**80.9**	**90.0**	**–**

StatLink http://dx.doi.org/10.1787/301485803421

. .: Not available.
1. 2003 agricultural area used in calculation.
2. Other countries include: Bulgaria, Colombia, Honduras, Indonesia, Philippines, Romania, Ukraine and Uruguay.
Source: ISAAA (2006).

There is a considerable and expanding effort within all OECD countries to ***conserve plant genetic resources*** and to maintain a broad base of genetic resources useful for crop improvement. The state of the *in situ* and *ex situ* plant genetic resources conservation efforts by OECD countries summarised in Table 1.8.2 provides a narrative on the development of plant genetic collections (*ex situ* genebanks) and field (*in situ*) conservation. Over 1 300 genebanks have now been established globally, containing over 6 million

Table 1.8.2. **Plant genetic resource conservation activities for OECD countries**

2004

	In situ conservation[1]		*Ex situ* conservation[1]		Institutions-programmes-databases[2]
	Status	Activities	Status	Activities	
Austria	n.a.	On-farm conservation.	I	8 000 accessions, 246 species.	ÖPUL-Program, Austrian Agency for Health and Food Safety.
Belgium	I	Fruit, vegetables, fodder grasses, horticultural varieties.	n.a.	n.a.	Department of Plant Genetics and Breeding of the Agricultural Research Centre.
Canada	I	Network of protected areas for native plant species.	I	> 100 000 accessions, 850 species.	Agriculture and Agri-Food Canada GRIN-CA database.
Czech Republic	I	On-going propagation of horticultural varieties.	I	52 000 acccessions including all major cereal crops, fruit plants, vegetables and grasses.	Research Institute of Crop Production EVIGEZ database.
Finland	S	Limited areas of conserved species, clonal archives of fruit and berries.	S	Contributor and member of Nordic Gene Bank.	National Plant Genetic Resources Programme initiated, Nordic Gene Bank.

Table 1.8.2. **Plant genetic resource conservation activities for OECD countries** *(cont.)*

2004

	In situ conservation[1]		*Ex situ* conservation[1]		Institutions-programmes-databases[2]
	Status	Activities	Status	Activities	
Germany	I	*In situ* conservation inventory and development (including on-farm management) of plant genetic resources in the framework of the National Programme; Promotion of *in situ* conservation of wild species related to cultivated plants and wild plants relevant to food.	S	Approx. 150 000 accessions of more than 2 000 species.	Information and Coordination Centre for Biological Diversity (IBV, *www.ble.de/*); National Work Programme on Plant Genetic Resources of Agricultural and Horticultural Crops (*www.genres.de/pgr/nationales_fachprogramm/*); Collections of Plant Genetic Resources in Germany (PGRDEU, *www.genres.de/pgrdeu/*).
Greece	I	New programme in field protection and cultivation of 77 species and local varieties.	S	Renewed effort 2003-08 to conserve endangered germplasm, presently 8 500 accessions.	Various Directorates of the Greek Ministry of Agriculture.
Hungary	I	On-farm conservation.	S	Over 100 000 accessions of which about a quarter are cereal accessions.	National Gene Bank Council and National Genetic Resources Database.
Italy	n.a.	n.a.	S	Significant accessions of major cereal crops.	Italian institutions as well as the FAO and the International Plant Genetics Research Institute
Korea	n.a.	National seed genebank is surveying the distribution of some wild relatives of crop species and diversity assessment of weedy types found on farmland.	I	113 702 accessions of cereal crops, 18 273 of industrial and medicinal plants, 13 820 of vegetables and fruit trees and 3 947 of forage crops.	National Seed Genebank.
Netherlands	n.a.	Limited activities are undertaken. Research into the diversity of traditional grassland is ongoing.	I	22 866 accessions covering 20 crops.	Centre for Genetic Resources (CGN).
New Zealand[3]	n.a.	Extensive conservation, much of which has formal legal protection as being part of national and local reserves systems but many ecosystems are under pressure, in particular from exotic animals and plant pests.	n.a.	A large part of the flora is represented in *ex situ* collections, but information exchange between collections is poorly coordinated.	The Department of Conservation and Ministry for the Environment developed a national strategy which includes public consultation since 1997.
Portugal	n.a.	On-farm conservation, mainly maize and beans.	I	37 500 accessions including all major cereal crops, common beans, fruit trees, aromatic and medicinal plants and some crop wild relatives.	INIAP and Banco Portugues Germoplasma Vegetal (seed and field banks), Regional Agricultura Services (field banks) and University Departments (seed banks).
Switzerland	S	On-farm conservation programmes for fruit, trees, forage crops, wine grapes and cereals.	S	13 400 accessions. 131 species.	National database under construction including all genetic resources conserved by public and private organisations.
Turkey	n.a.	15 species are under conservation. Accession number is unknown.	n.a.	52 920 accessions from 657 genus are available in the seed bank, with 5 944 accesions of vegetative material in gene banks.	Aegean Agricultural Research Institute (AARI) seed bank, AARI field bank, central Research Institute for Field Crops gene bank.
United Kingdom	n.a.	Inventory of *in situ* plant genetic resources under way.	S	> 130 000 accessions in gene banks.	Numerous government and university departments, Kew Royal Botanic Gardens.
United States	n.a.	n.a.	I	US National Plant Germplasm Sytem maintained 450 000 accessions, 10 330 species.	Agricultural Research Service, US Department of Agriculture.

StatLink http://dx.doi.org/10.1787/301534422511

n.a.: Not available. I: Increasing. S: Stable.

Source:

1. OECD Agri-environmental Indicators Questionnaire, unpublished.
2. OECD Agri-environmental Indicators Questionnaire, unpublished, and International Plant Genetic Resources Institute database.
3. Conservation and Use of Plant Genetic Resources, Ministry of Agriculture Policy Public Information Paper 12 (June 1996).

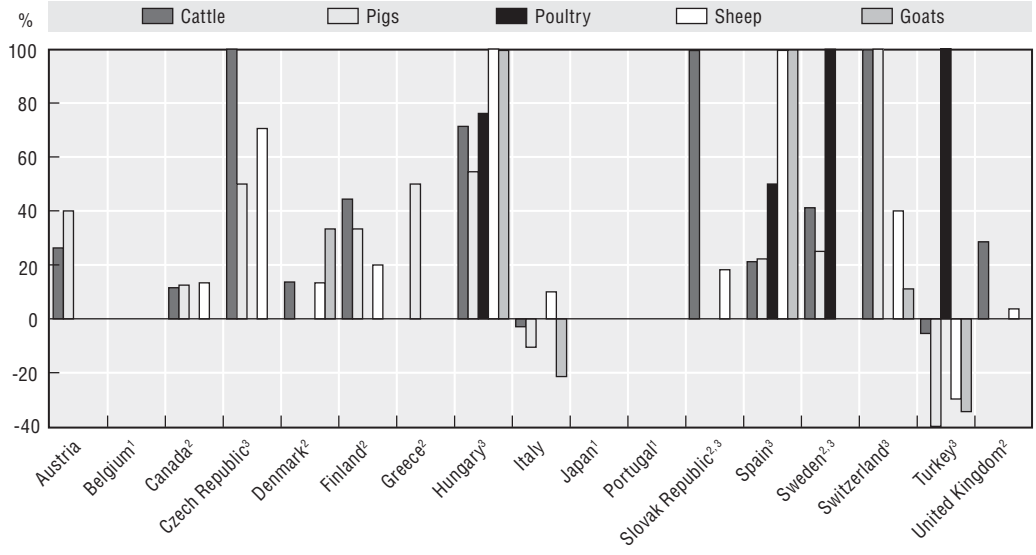
accessions (FAO, 1996). The **United States** has one of the world's largest collections of plant samples in its genebanks and conserves almost half a million different samples, distributing more than 100 000 samples annually.

Genetic conservation is moving beyond just crop genebanks, the traditional *ex situ* conservation method, to include more *in situ* conservation efforts (Table 1.8.2). In part, this stems from the recognition that certain key elements of crop genetic resources cannot be captured and stored off-site, and that when plants are left in the field they naturally continue to generate new genetic resources and provide natural laboratories for research. *In situ* conservation helps to counter the loss of crop varieties from genebanks, and ultimately provides a backup to gene bank collections. There are limited data, however, on endangered crop varieties to decipher any OECD wide trends (Chapter 2).

Agricultural livestock genetic resources. Livestock genetic diversity for OECD overall, like crops, suggest that there is ***increasing diversity of livestock breeds*** used in production (1990-2002), but the extent to which this is improving the environmental resilience of livestock production systems and lowering risks to pathogens and disease remains unclear. The number of livestock breeds registered for marketing and as a share of overall livestock numbers increased, except for some livestock breeds in **Italy** and **Turkey** (Figure 1.8.4). There was also a reduction in most countries of the share of the major livestock breeds in total livestock numbers a further sign of increasing diversity, notably for

Figure 1.8.4. **Change in the number of livestock breeds registered and certified for marketing**

% change 1990-2002



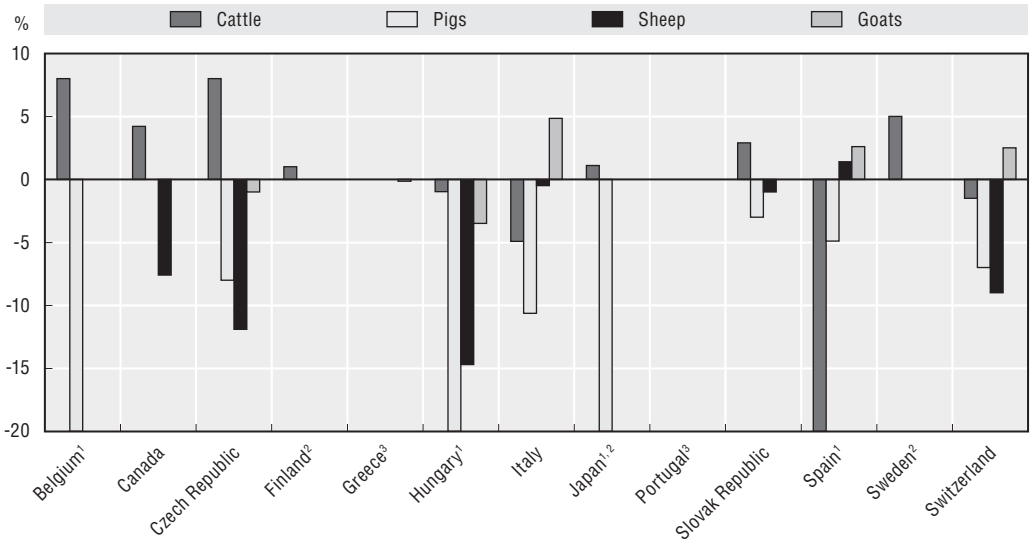
StatLink http://dx.doi.org/10.1787/288005800684

1. For Belgium, Japan and Portugal there was no change in the number of breeds registered or certified for marketing between 1990 and 2002.
2. Percentages are equal to zero for Canada (goats), Denmark (pigs, poultry), Finland (poultry), Greece (cattle, poultry, sheep, goats), Slovak Republic (pigs), Sweden (sheep), United Kingdom (pigs).
3. For the Czech Republic cattle data are 157%. For Hungary sheep data are 150% and goat data are 300%. For Slovak Republic cattle data are 267%. For Spain sheep data are 113% and goat data are 175%. For Sweden poultry data are 100%. For Switzerland cattle data are 167% and pig data are 100%. For Turkey pig data are –75% and poultry data are 167%. Data for the year 2002 refer to the year 2000.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

Figure 1.8.5. **Change in the share of the three major livestock breeds in total livestock numbers**

Change in the share of three major livestock breeds in total livestock numbers between 1990 to 2002 (for each category of livestock)



% share in 2002

	Cattle	Pigs	Sheep	Goats
Belgium	90	29	. .	. .
Canada	99	. .	45	. .
Czech Republic	98	81	46	99
Finland	100	100	100	. .
Greece	98	93	68	100
Hungary	92	52	79	97
Italy	88	88	95	99
Japan	99	70	100	. .
Portugal	50	. .	40	40
Slovak Republic	98	94	97	. .
Spain	28	6	28	30
Sweden	90	90	95	95
Switzerland	97	93	77	72

StatLink http://dx.doi.org/10.1787/288015542514

n.a.: Not available.

Note: The hybrid, cross livestock breeds (class "Other") are not included in this indicator calculation although this class represents the biggest percentage (60%, 70%, 80% and 90%) of all categories.

1. Refers only to Flanders, pig data are –51%. For Hungary pig data are –33%. For Japan pig data are –28%. For Spain cattle data are –25%.
2. Percentages are zero per cent for Finland (pigs, sheep), Japan (sheep) and Sweden (goats).
3. For Greece and Portugal there was no change in the number of breeds registered or certified for marketing between 1990 to 2002.

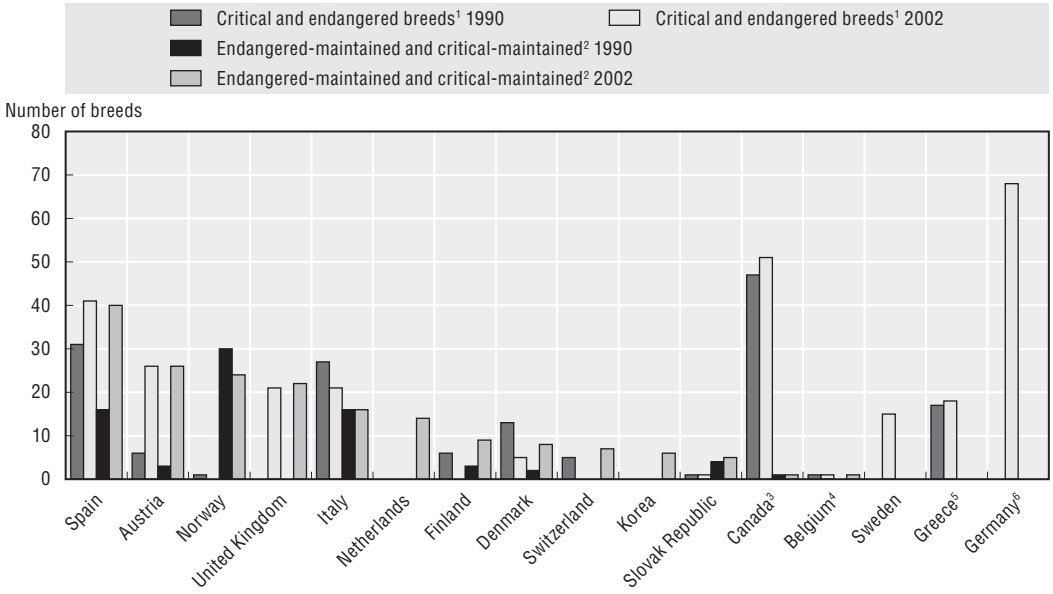
Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

pigs, although for some countries the share for major cattle and goat breeds increased (Figure 1.8.5). The dominance of a few breeds in total livestock numbers is more pronounced than for crops, especially cattle which are mainly in excess of 90% (Figure 1.8.5).

Concerning OECD trends (1990-2002) for the number of ***endangered and critical livestock breeds*** (total of cattle, pigs, poultry and sheep) there is a mixed picture, increasing in some cases (**Austria, Canada, Spain**) and declining for others (**Denmark, Greece, Italy**) (Figure 1.8.6). In some countries indigenous breeds are being replaced by a few high

Figure 1.8.6. **Total number of cattle, pigs, poultry and sheep in endangered and critical risk status and under conservation programmes**

1990 and 2002



	Critical and endangered breeds[1]		Endangered and critical breeds under maintained (conservation) programmes[2]	
	Number			
	1990	2002	1990	2002
Spain	31	41	16	40
Austria	6	26	3	26
Norway	1	. .	30	24
United Kingdom	. .	21	. .	22
Italy	27	21	16	16
Netherlands	. .	. .	. .	14
Finland	6	. .	3	9
Denmark	13	5	2	8
Switzerland	5	. .	. .	7
Korea	. .	. .	. .	6
Slovak Republic	1	1	4	5
Canada[3]	47	51	1	1
Belgium[4]	1	1	. .	1
Sweden	. .	15	. .	. .
Greece[5]	17	18	. .	. .
Germany[6]	. .	68	. .	. .

StatLink http://dx.doi.org/10.1787/288042207583

n.a.: Not available.

1. *Critical:* The total number of breeding females is less than or equal to 100 or the total number of breeding males is less than or equal to 5; or if the overall population size is less than or equal to 120 and decreasing the percentage of females being bred to males of the same breed is below 80%. *Endangered:* the total number of breeding females is greater than 100 and less than or equal to 1 000 or the total number of breeding males is less than or equal to 20 and greater than 5; or if the overall population size is greater than 80 and less than 100 and decreasing and the percentage of females being bred to males of the same breed is above 80%; or if the overall population size is greater than 1 000 and less than or equal to 1 200 and decreasing and the percentage of females being bred to males of the same breed is below 80%.
2. This category identifies populations for which active conservation programmes are in place or those that are maintained by commercial companies or research institutes.
3. Data for pigs and sheep 1990 refer to 1995.
4. Data only for Flanders refer to cows.
5. Data for 1990 refer to 1985.
6. Data for cattle, pigs and sheep 2002 refer to 2000.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

production breeds (OECD, 2003b; 2004b). Across different livestock categories considered within the endangered and critical risk category, cattle and sheep breeds have the highest numbers of breeds at risk relative to pigs and poultry for most countries in 2002. There is also an issue of the change in number of animals within an endangered breed, but there is little data on this across OECD countries. For example, in **Norway** for one of its endangered cow breeds (the Norwegian West Coast cow) numbers have decreased over the past decade from 500 to 200 remaining animals (Chapter 3).

Most countries have implemented ***conservation programmes*** designed to protect and enhance the populations of endangered and critical livestock breeds, and the number of breeds included under these programmes increasing (Figure 1.8.6). **Canada** is a notable exception, with only 1 out of 51 critical and endangered livestock breeds within a conservation programme in 2002 (Figure 1.8.6), although efforts to expand conservation are underway (Table 1.8.3). Moreover, most countries report an increasing number of semen samples stored *ex situ* in genebanks and an expanding number of activities for *in situ*

Table 1.8.3. **Livestock genetic resource conservation activities for OECD countries**

2004

	In situ conservation[1]		*Ex situ* conservation[1]		Institutions-programmes-databases
	Status	Activities	Status	Activities	
Austria	S/I	ÖPUL 2000 measure covering breeding of endangered breeds.	S/I	Austrian Gene Bank stores semen and DNA from all endangered Austrian breeds. Live animal collections in zoos.	n.a.
Canada	I	Many new areas are identified each year based on their uniqueness.	I	Continue to expand its conservation efforts. Database has developed to reflect its national farm holdings.	Canadian livestock gene bank, Database (GRIN-CA).
Czech Republic	I	Cattle (2), sheep (1, since 1998: 2 breeds), goats (2), pig (1), horses (5), poultry (2), later also rabbits (7), nutrias (3), fish (7) and honey bees (1) are covered in the National Programme.	I	Gene bank collect semen, embryos and blood/DNA samples.	National Programme (since 1995), Gene bank (since 2000).
European Union	n.a.	The Community programme for conservation of genetic resources (*in situ* and *ex situ* conservation) and the agri-environmental measures to support breeds in danger of being lost to farming (*in situ*). In 2001, 138 800 endangered livestock units under protection schemes.		The Community programme for conservation of genetic resources (*in situ* and *ex situ* conservation).	n.a.
Finland	I	1985: 2 breeds, 2002: 9 breeds (all endangered ones).	n.a.	No programme yet, but strategic plan ready.	The National Animal Genetic Resources Programme was finalised in 2004.
Germany	S	46 breeds (horses 13, cattle 12, sheep 13, goats 3, pigs 5), 76 measures, in total.	S	Semen stored as cryopreserved.	Information and Coordination Centre for Biological Diversity (IBV, *www.ble.de/*); National Work Programme on Animal Genetic Resources (*www.genres.de/tgr/nationales_fachprogramm/*); central documentation of Animal Genetic Resources in Germany (TGRDEU: *www.genres.de/tgrdeu/*).
Greece	I	Number of rare breeds which include cattle, sheep, goat and horses are increased to 32 857 (in 2002) from 26 774 (in 1999).	n.a.	Supporting and enhancing research.	Agri-environmental Programme was implemented in 1998, and was last amended in 2003.
Ireland[2]	I	Provide financial support towards the *in situ* conservation of endangered native breeds.	I	Kerry Cattle Society. No *ex situ* conservation for cattle (except Kerry), horse and sheep.	Rural Environmental Protection Scheme (REPS) (since 1994), database: Cattle Movement Monitoring System (CMMS- the national database identifying all bovines).

Table 1.8.3. **Livestock genetic resource conservation activities for OECD countries** *(cont.)*

2004

	In situ conservation[1]		*Ex situ* conservation[1]		Institutions-programmes-databases
	Status	Activities	Status	Activities	
Mexico	n.a.	Some conservation efforts by public universities and research stations are being done for cattle, pigs, sheep and poultry.	n.a.	A conservation project of a horse criollo breed is being carried out on a military farm.	There are organised conservation programmes.
Netherlands	I	Growing interest can be noted for *in situ* conservation for rare breeds of Dutch origin, taking into account new functions of farm animals (recreation, nature/landscape management).	I	Growing number of breeds has been cryo-conserved in gene bank.	Database is available at the Centre for Genetic Resources.
Norway	n.a.	n.a.	I	Collection and storage of genetic material as semen.	n.a.
Portugal	n.a.	Producers receive financial support to maintain breeds which are threatened. In addition, a mating plan aimed at maintaining within breed genetic diversity is underway.	n.a.	A comprehensive programme aimed at *ex situ* conservation of germplasm samples of all native breeds of livestock is underway.	n.a.
Slovak Republic	n.a.	The preservation is related approximately to 5 000 cows (2 breeds) and 5 000 ewes (3 breeds). Few native and locally adapted horse and poultry breeds are under support programmes.	n.a.	With main species, cryoconservation of semen in cattle was established. ID of 43 bulls (on average 500 per bull) are preserved.	Basic principles of *in situ* and *ex situ* conservation methods are defined by Act No. 194 of 1998 on Farm Animal Breeding.
Spain	n.a.	From 1997 to 2004, 10 new horse breeds have been recognized (out of a total of 20 indigenous breeds), 7 (out of 34) cattle, 25 sheep (out of 42), 10 goats (out of 22) and 2 (out of 6) pigs. Most of them have recognised associations and programmes approved.	n.a.	Gene bank collect semen, embryos and blood/DNA samples. The national Commission of the Ministry of Agriculture for reproduction co-ordinates the activities.	The Spanish livestock breeds Committee of the Ministry of Agriculture approves new breeds, co-ordinating the work of the autonomous regional authorities and the scientific institutions. A Spanish national programme and database is implemented.
Switzerland	n.a.	Most of the conservation measures are implemented *in situ*: since 1999 appropriate conservation programmes have been started regarding the endangered Swiss breeds. Programmes are underway for 9 breeds (6 endangered breeds and 3 for breeds under observation).	n.a.	The conservation of breeds of goats, the Freiberger horse and Evolène bovines are aided by *ex situ* projects (setting up of sperm banks).	n.a.
Turkey	n.a.	Native breeds covering 4 cattle, 4 sheep, 1 goat, 2 poultry, 1 water buffalo, 1 rabbit and 1 bee and 3 silkworm lines have been conserved at Research Institutes of the General Directorate of Agricultural Research.	n.a.		Animal genetic resource conservation project (since 1995).
United Kingdom[3]	n.a.	Conservation has been in the hands of NGOs. Breed analysis, niche marketing, traditional breed incentive and scrapie genotyping (only for sheep) are going on.	n.a.	Cattle, equine, goat, pig and sheep: semen and blood stored.	The Rare Breeds Survival Trust (RBST), UK national database on AnGR (since 1997).
United States	S	Primarily a private sector activity. There is no financial assistance to producers that maintain rare breeds *in situ*.	I	Development of cryopreserved germplasm samples for all livestock breeds.	A national effort was initiated in 1999 (*ex situ*).

StatLink http://dx.doi.org/10.1787/301534783708

n.a.: Not available. I: Increasing. S: Stable.

Source:

1. OECD Agri-environmental Indicators Questionnaire, unpublished.
2. Ireland's Farm Animal Genetic Resources country report to the FAO.
3. UK's Farm Animal Genetic Resources country report to the FAO (2002).

conservation of rare breeds (Table 1.8.3). Although not shown in Table 1.8.3, **Australia** has no conservation programmes for rare breeds or livestock genebanks, and in a number of other countries *in situ* conservation of rare breeds is undertaken by voluntary societies.

1.8.2. Wild species diversity

Indicator definitions:

- Wild species that use agricultural land as primary habitat.
- Populations of a selected group of breeding bird species that are dependent on agricultural land for nesting or breeding.

Concepts and interpretation

Agriculture is the major land user in many OECD countries (Section 1.1). As such, agriculture has a direct impact on species' habitats and indirect impacts on the existence of the species themselves, but the interactions and relationships that control impacts are complex (Figure 1.8.1). Moreover, the consequences of farming activities on wild species are especially important in those OECD countries (*e.g.* **Australia, Mexico**) which have a "megadiversity" status (*i.e.* countries with a high share of the world's wild flora and fauna species).

There has been progress made with methods to calculate some indicators of wild species biodiversity related to agriculture (OECD, 2003a). However, there are few comparative, quantitative data available relating to the status of wild flora and fauna species associated with agriculture across OECD countries. The notable exception are bird populations, although more data are also becoming available on butterflies, but for flora the data are much poorer.

Birds can act as "indicator species" providing a barometer of the health of the environment. The indicator used in this section mainly draws on BirdLife International's (BI) bird population dataset. BI treats data with statistical techniques that enable calculation of national species' indices and their combination into supranational indices for species, weighted by estimates of national population sizes (BirdLife International, 2004). Weighting allows for the fact that different countries hold different proportions of each species' population. Supranational indices for species were then combined (on a geometric scale) to create multi-species indicators, fixed (for the purpose of presentation) to a value of 100 in 2000.

Wild species that provide essential services to agriculture such as pollinators, predators and soil biota, and a vast array of microbial species that contribute indirectly to food production, are rarely assessed. But some countries, however, are beginning to monitor these aspects of agri-biodiversity under national biodiversity strategies (OECD, 2003a), especially for soil biodiversity (Chapter 2; OECD, 2004c).

Interpretation of indicators related to wild species using of agricultural land as a primary habitat for feeding and/or breeding need to be treated cautiously. While populations of flora and fauna are impacted by agricultural activities, such as the loss of habitats on farmland, many other factors external to farming also affect population dynamics, such as changes in populations of "natural" predators, the weather, and over longer periods of climate change. A further issue is defining primary agricultural habitat,

as some species may use farmland as a feeding area but breed in an adjoining forest, while changes in adjacent ecosystems may themselves affect species using farmland. Setting baselines from which to assess changes in wildlife populations also raises a number of issues. As for the other indicators in this report the early 1990s is used as the baseline period from which to assess change, but other baselines can be relevant, such as 1992, the time of the CBD agreement (OECD, 2003a).

Overall changes in farming management practices and systems (Section 1.9) and the intensity of input use, especially nutrients (Section 1.2), pesticides (Section 1.3) and water (Section 1.6), are the key ***driving forces*** that link to the ***state*** of wild species related to farming and ***responses*** in terms of wild species conservation programmes as part of broader agri-biodiversity management plans (Section 1.9).

Recent trends

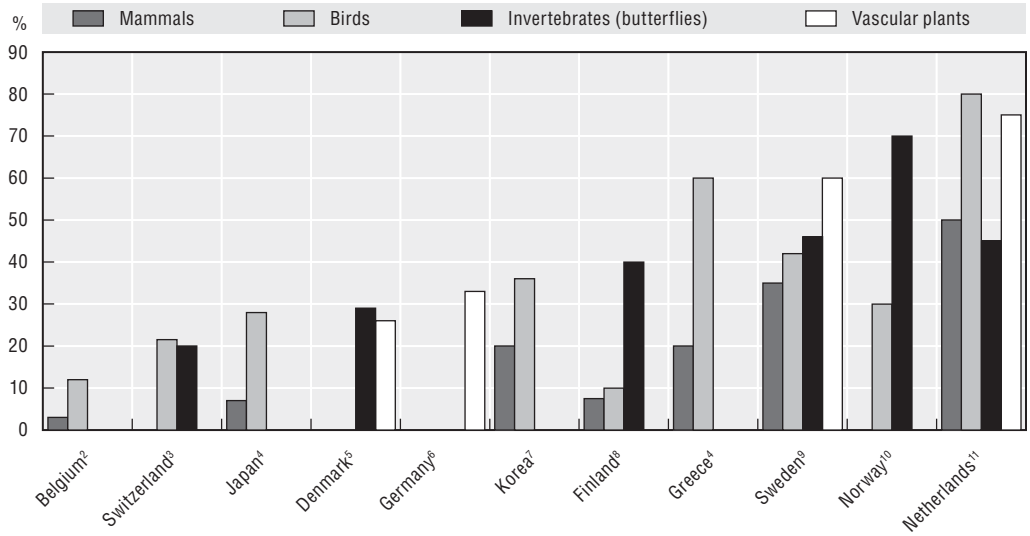
In many OECD countries agriculture is a major primary habitat for certain populations of wild species, and provides habitat for the remaining species following the conversion of "natural" habitat to farmland (Figure 1.8.7). This is particularly the case for birds and to a lesser extent butterflies, but for flora the situation is variable across countries, and for mammals farmland is less important as a habitat in many cases. In a few countries (notably **Japan** and **Korea**) where paddy rice agriculture is widely practised, this system of farming can also provide habitat for fish, amphibians and reptiles depending on the management practices. Also, some countries report that agriculture is the major threat to the nation's endangered wild species (**France, United States**, Chapter 3). The importance of agricultural land for wild species should also be viewed in the context that farming accounts for almost 40% of total OECD land use (2002-04), although the total OECD agricultural land area declined by almost 4% over the period 1990 to 2004 (Section 1.1.3).

Trends in OECD farmland bird populations showed a decline over the period 1991 to 2004 (Figure 1.8.8). In many cases the decrease in farmland bird populations was much less pronounced than had occurred over the 1980s, and for some countries populations have been rising since the early 2000s. This is partly associated with efforts beginning in the 1990s to introduce agri-environmental schemes aimed at encouraging bird conservation (BirdLife International, 2004). In other cases changes in farm management practices, such as increasing the area under conservation tillage has increased feed supplies for wild species (**United States**). Toxic effects of pesticides on wild species (*e.g.* birds, worms, aquatic species) has been declining over recent years (see Section 1.3.2) in **Belgium, Denmark, Germany**, and the **Netherlands**.

In other countries there has been a marked reduction in bird populations (*e.g.* **Canada, France**, Figure 1.8.8). In **France**, while the decline in farmland birds was more than –10% over the period 1990 to 2004, the decrease in the national average bird populations was –3% only (Chapter 3). Agriculture's continued pressure on biodiversity in most countries, is largely explained by greater use of pesticides and nutrients (leading to eutrophication of aquatic habitats), the loss of habitat (*e.g.* draining wetlands), overgrazing, lowering of groundwater tables and river flows, field consolidation, and for a few countries expansion in the area farmed. This has damaged not only bird populations but has also adversely affected populations of invertebrates (see EEA, 2005 on European butterfly populations), mammals and flora in many countries, both terrestrial and aquatic species in fresh water

Figure 1.8.7. **Share of selected wild species that use agricultural land as primary habitat**[1]

Late 1990s/early 2000s



StatLink http://dx.doi.org/10.1787/288048714854

Note: Data are not available for all categories of wild species for all countries.

1. These data should be interpreted with care as definitions of the use of agricultural land as habitat by wild species can vary. Species can use agricultural land as "primary" habitat (strongly dependent on habitat) or "secondary" habitat (uses habitat but not dependent on it).
2. Data represent only Flanders; data for invertebrates and vascular plants are not available.
3. Data for vascular plants are not available, data for birds and butterflies from OECD (2003a).
4. Data for invertebrates and vascular plants are not available.
5. Data for mammals and birds are not available.
6. Data for mammals, birds and invertebrates are not available; it is estimated that about 50% of all wild species (animals and plants) depend on agricultural habitats.
7. Data for invertebrates and vascular plants are not available; data from OECD (2003a).
8. Data for mammals are between 5% and 10%. Data for vascular plants are not available; data for butterflies 2002, from OECD (2003a).
9. Invertebrates: butterflies, beetles, aculeata hymenoptera, a number of smaller groups, plus an estimate of flies (diptera) and other hymenoptera. Overall the Swedish estimate is based on about one third of the known number of invertebrate species in Sweden.
10. Data for mammals and vascular plants are not available
11. Share of all wild species on agricultural land classified into high, moderate, and low dependence; mammals: including rodents; birds: breeding birds.

Source: OECD Agri-environmental Indicators Questionnaires, unpublished.

and coastal areas (Chapter 3). In **Australia**, for example, agriculture has been identified as the major source of pollution threatening the Great Barrier Reef, a major marine coral aquatic ecosystem, and now included as a UNESCO World Heritage Site (Chapter 3).

1.8.3. Ecosystem diversity

Indicator definitions:

- Conversion of agricultural land area to (land exits) and from (land entries) other land uses (*i.e.* forest land; built-up land, wetlands, and other rural land).
- Area of agricultural semi-natural habitats (*i.e.* fallow land, farm woodlands) in the total agricultural land area.
- National important bird habitat areas where intensive agricultural practices are identified as either posing a serious threat or a high impact on the area's ecological function.

Figure 1.8.8. **Population trends of farmland birds**

2000 = 100[1]

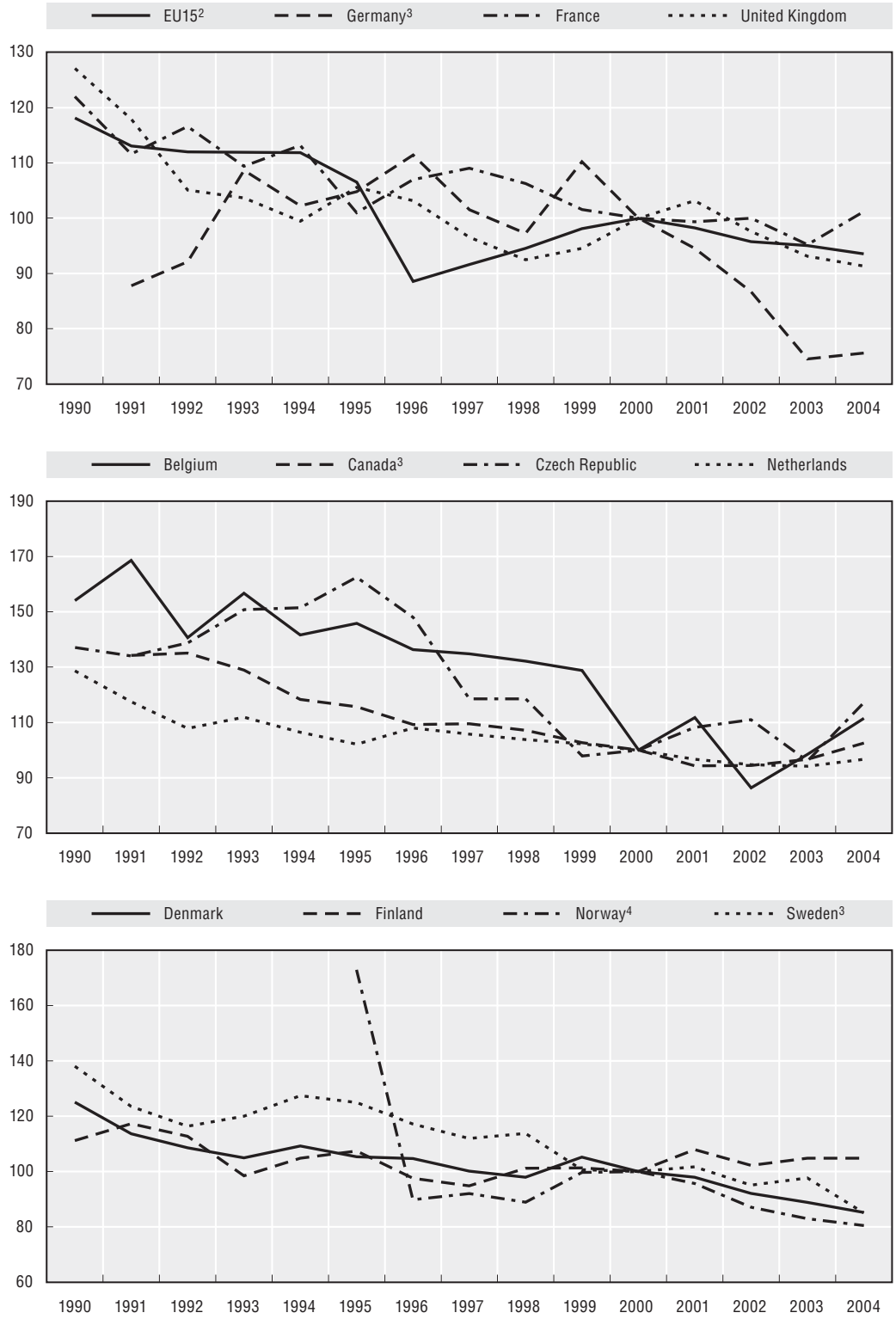
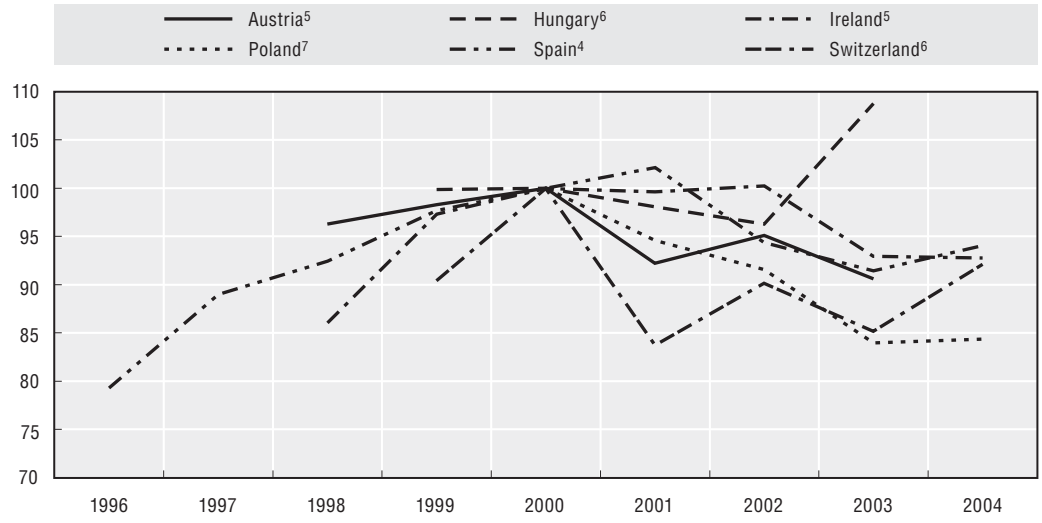


Figure 1.8.8. **Population trends of farmland birds** *(cont.)*

2000 = 100[1]



StatLink http://dx.doi.org/10.1787/288057486058

1. Aggregated index of population estimates of a selected group of breeding bird species that are dependent on agricultural land for nesting or breeding. For detailed notes, see *www.epp.eurostat.cec.eu.int*.
2. For EU15, values are estimated.
3. Values are not available for the following countries: Canada (1990), Germany (1990).
4. For 1990-95 values are not available for the following countries: Norway, Spain.
5. For 1990-97: Austria and Ireland.
6. For 1990-98 values are not available for the following countries: Switzerland and Hungary.
7. For 1990-99: Poland. National data.

Source: Pan-European Common Bird Monitoring Scheme (2007); Canadian Wildlife Service National Site (CWS).

Concepts and interpretation

Despite increasing scientific knowledge of the ecological functions of biodiversity, habitat monitoring and assessment systems are, for most OECD countries, poor in terms of disaggregated time series. Many countries, however, are beginning to make an effort to monitor changes in semi-natural and uncultivated habitat areas on farmland as part of a broader national biodiversity management plan. Even so, by examining net conversions of agricultural land to other ecosystems (*e.g.* forests), changes in areas of semi-natural and uncultivated habitats on farmland, as well as the share of important bird habitat areas impacted by agriculture, some estimate of overall ecosystem diversity can be inferred.

The indicator of the net conversion of agricultural to other land uses, is calculated as the difference between land converted to agricultural use (land entry) and land leaving agriculture (land exit), covering wetlands, forests, built-up areas (*i.e.* for urban use and transport) and other rural land uses, such as land left to grow in a "wild" state. Although these land classes are broadly defined, nevertheless, they provide some idea of the likely impacts on biodiversity from agricultural land use changes, but these changes need to be interpreted carefully. For example, while the conversion of farmland to a forest can be beneficial to biodiversity, it will depend on both the quality of farmed habitat loss to forestry and also whether the forest is developed commercially or left to develop naturally. The conversion of a mountain pasture area that may support a rich variety of wild flora and fauna to a forest planted to a monoculture of pines, for example, could be detrimental for biodiversity. Also for some countries wetlands can be farmed (*e.g.* grazed water meadows, and paddy fields), but their importance for supporting wildlife will depend on how they are

managed, especially in terms of livestock densities, farm chemical input use, and cultivation practices. However, conversion of farmland to urban use will lead to the loss of biodiversity, especially changing farmland to artificial surfaces (soil sealing).

Tracking changes in the area of agricultural semi-natural habitats provides information on the extent of land that is subject to relatively "low intensity" farming practices, such as wooded pastures and extensive grasslands with little, if any, use of fertilisers and pesticides used in their management, or not farmed at all, such as fallow land (uncultivated habitats on farmland, such as hedges, are examined in Chapter 2). A major difficulty in assessing changes in semi-natural habitats on agricultural land is their definition in terms of what constitutes "semi-natural" across different farming systems and countries, although international agreements, such as the CBD, are beginning to address this issue. A further limitation of this indicator is that at present, for most countries, data of semi-natural habitats are collected at fairly broad levels of aggregation which impairs analysis of potential impacts on biodiversity.

BirdLife International have developed an information base on *Important Bird Areas* (IBAs) across most OECD countries. The IBAs are defined by BirdLife International as prime bird habitat that is likely to support a range of other species as well. As such, changes and threats to the IBAs can be seen as a proxy measure of changes and threats to wildlife habitats more broadly. The indicator shows the share of nationally-designated IBAs where intensive agricultural practices have been identified as either posing a serious threat or a high impact on the area's ecological function (*i.e.* its ability to provide suitable habitat for birds). The determination of what constitutes a serious impact or threat is an estimate provided by local experts as part of each national IBA inventory. BirdLife International has compiled and maintained an IBA database as part of the World Bird Database, with research currently underway to extend the database to **North America, Australia and New Zealand**. An important limitation of the IBA indicator is that what constitutes a serious impact or threat from farming is to a large extent based on local expert judgement and not quantitative time series, while these judgements may vary between regions and countries (EEA, 2005).

As with species diversity indicators, the ***state*** of agricultural ecosystem diversity are impacted by a range of ***driving forces*** that affect the quality and quantity of habitats on farmland, including changes in overall agricultural production, land use changes (Section 1.1), and farm management practices and systems (Section 1.9), which relate to ***responses*** in terms of habitat conservation programmes as part of broader agri-biodiversity management plans (Section 1.9).

Recent trends

For nearly all OECD countries there was a net conversion of agricultural land to other land uses (land exit) over the period 1990-92 to 2002-04, with a few exceptions (**Belgium, Luxembourg, Mexico, Norway, Turkey**) (Section 1.1). The conversion of agricultural land was mainly for forestry and urban development, with much smaller areas converted to wetlands and other land uses (Figure 1.8.9). The conversion of land from agricultural production to forest cover, provides a new and possibly more varied habitat for wild species in these areas, but the impacts on biodiversity are largely unknown. Only **Korea** and **Norway** showed net conversions of forest land into agricultural production (Figure 1.8.9), although **Australia** and **Mexico** (not shown in Figure 1.8.9) experienced high rates of clearance of native vegetation (especially temperate and tropical forests), much of it converted for agricultural use (Chapter 3).

Figure 1.8.9. **Change in agricultural land use and other uses of land**[1]

1985-2003[1]

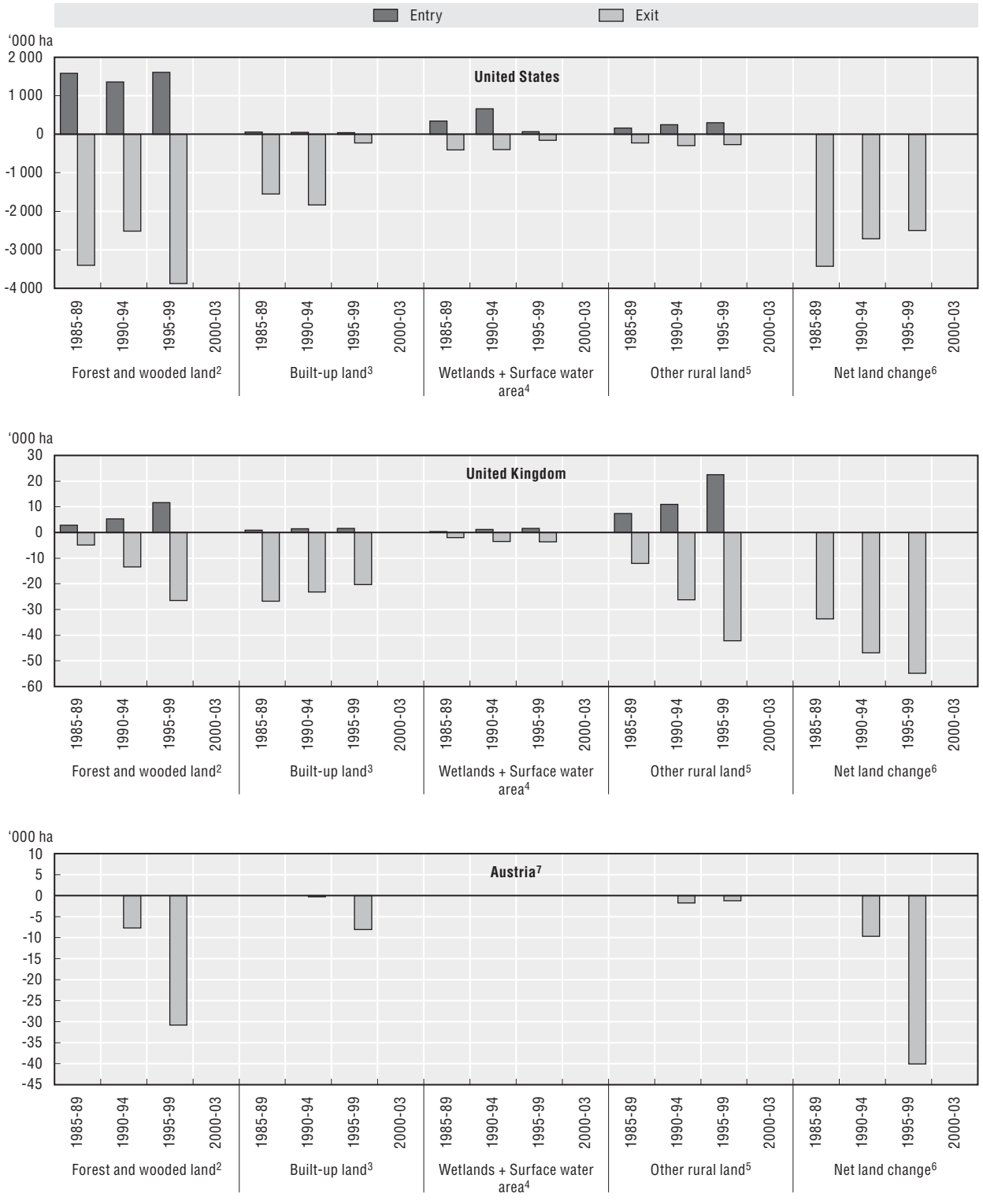


Figure 1.8.9. **Change in agricultural land use and other uses of land**[1] *(cont.)*

1985-2003[1]

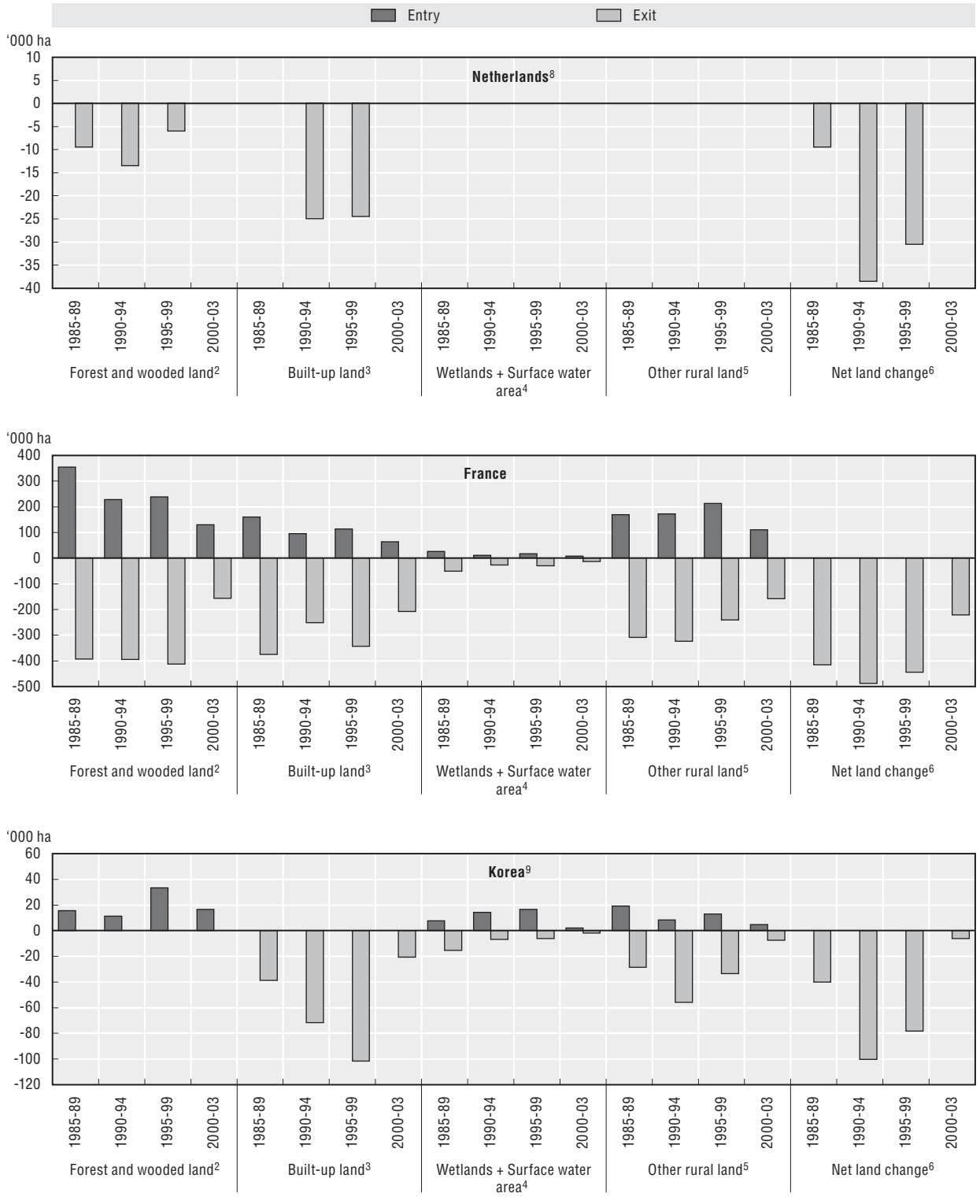
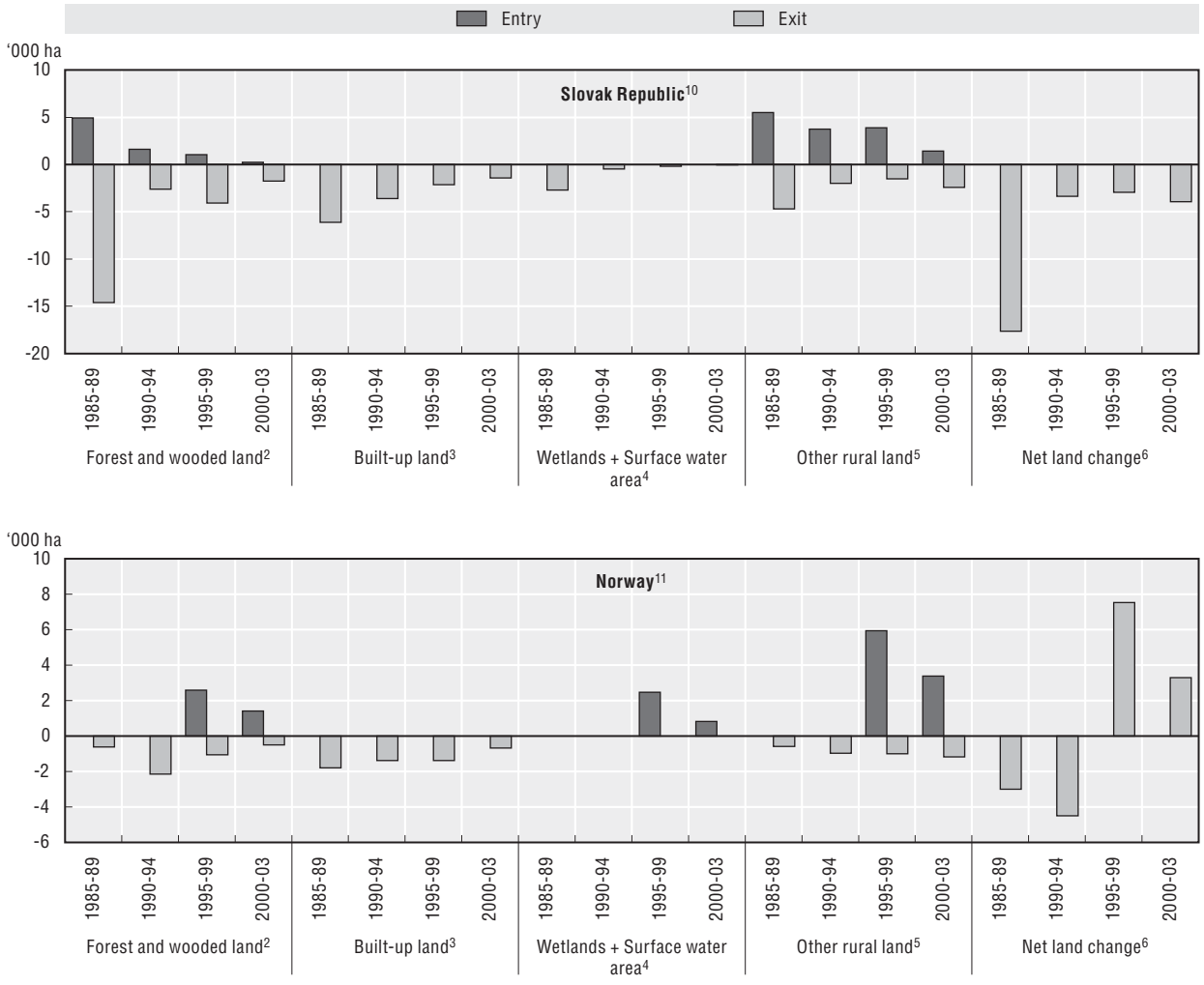


Figure 1.8.9. **Change in agricultural land use and other uses of land**[1] *(cont.)*
1985-2003[1]



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1. The figure shows "Land entries", *i.e.* land changed from other uses to agricultural use; "Land exits", *i.e.* agricultural land changed to other uses; and "net change", *i.e.* land entries minus land exits. For Austria, the Netherlands, the United Kingdom and the United States, data for 2000-03 are not available.
2. Forest land includes forest and wooded land.
3. Built-up land covers mainly land used for urban or industrial development and transport infrastructure, *e.g.* roads.
4. Wetlands include wetlands and surface water areas; surface water covers mainly small ponds, lakes and diverted rivers.
5. Other rural land mainly includes land that is not used for any of the above uses, such as abandoned land.
6. Net land change is the sum of forest land, built-up land, wetlands and other rural land.
7. For Austria land entry data are not available.
8. For the Netherlands, land entry data are not available, value of land exit for wetlands equals 0.
9. For Korea, land entry values for built-up land and land exit values for forest land equal 0.
10. For the Slovak Republic land entry values for built-up land and wetlands equal 0 for period 1985 to 2003, value for wetlands exit is 716 ha in 2000-03.
11. For Norway land entry value for built-up land and land exit value for wetlands equals 0.

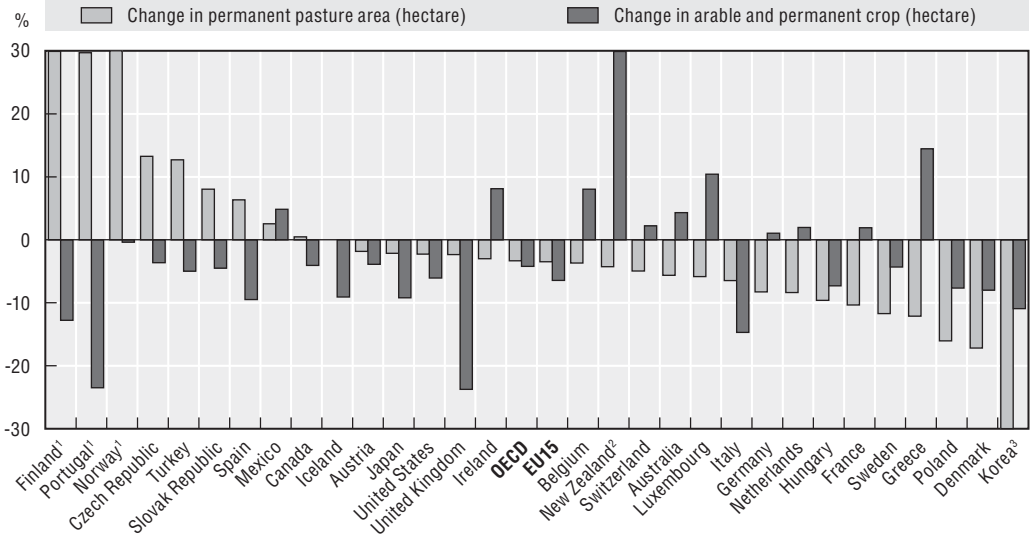
Source: OECD Secretariat; national data.

The picture of ***wetland conversion*** is mixed across OECD countries over the period 1985-89 to 2001-03, with a net loss of wetlands converted to agricultural use, although at a declining rate of loss, in **Korea** and **Norway**, in addition to **Italy** and **Japan** not shown in Figure 1.8.9 (Chapter 3). In **France**, the **Czech** and **Slovak Republic**, the **United Kingdom** and the **United States** (1992-2004) there was a net gain in wetland areas converted from agricultural use (Figure 1.8.9). While the total areas of wetland conversion, into or out of agricultural production, were only a small share of the total farmed area, wetlands are highly valued habitats for biodiversity and their loss is of international significance as recognised through both the CBD and the Convention on Wetlands (Ramsar Convention). Even when agricultural land is converted back to a wetland it may take many decades or longer, for the wetland to be restored to its "natural" state. For some countries, however, the conservation and loss of farmed wetland habitats (*e.g.* grazed water meadows, and paddy fields under certain management conditions) is also an issue, but data on the extent of these farmed wetlands are poor (a few paddy field sites in **Japan** are designated by the Ramsar Convention as wetlands of international importance, see *www.ramsar.org/profile/profiles_japan.htm*).

A major share of agricultural semi-natural habitats consists of ***permanent pasture***, which for most OECD countries declined during the period 1990-92 to 2002-04, with the notable exceptions of **Finland, Norway** and **Portugal**, and to a lesser extent **Canada, the Czech** and **Slovak Republics, France, Mexico, Spain** and **Turkey** which increased (Figure 1.8.10). Despite the reduction in the permanent pasture area it still remains the dominant farmland use in most OECD countries (Figure 1.8.11). Much of the reduction in the permanent pasture area was land converted to forestry, although for some countries pasture has also been converted

Figure 1.8.10. **Permanent pasture and arable and permanent cropland**

1990-92 to 2002-04



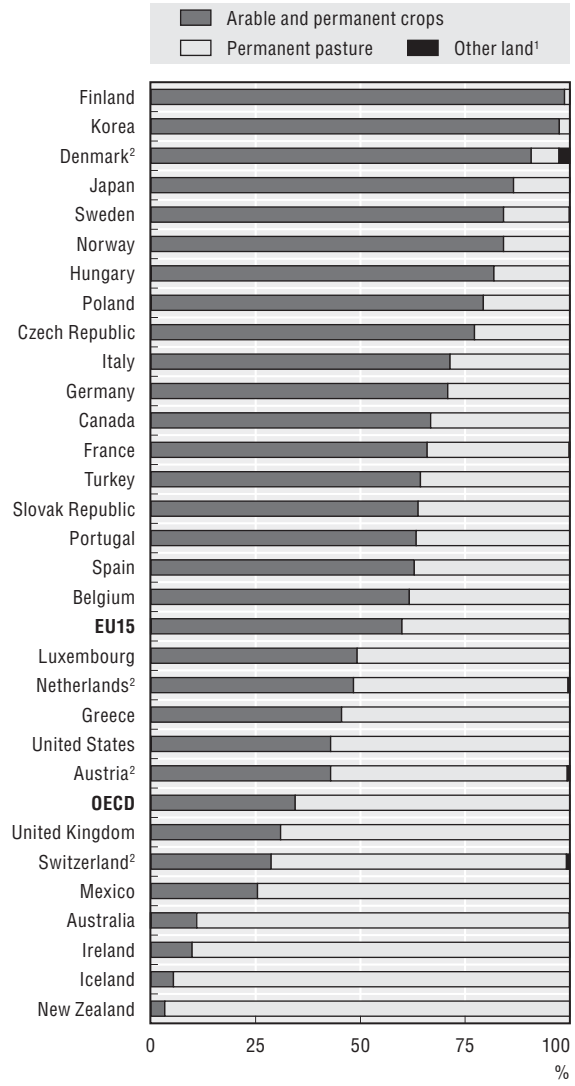
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1. Percentage change greater than 30%: Finland 84%, Portugal 61%, Norway 40%. For Norway, change is partly due to improved reporting.
2. Change in arable and permanent crop land for New Zealand is 54%.
3. Change in permanent pasture area for Korea are –48%.

Source: FAOSTAT (2006); national data for Austria, Belgium, Canada, the Czech Republic, Denmark, France, Germany, Hungary, Iceland, Ireland, Japan, Korea, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain and Turkey.

Figure 1.8.11. **Share of arable and permanent cropland, permanent pasture and other agricultural land in total agricultural land area**

Percentage share in agricultural land, average 2002-04



	Change in arable and permanent crops area	Change in permanent pasture area
	1990-92 to 2002-04	1990-92 to 2002-04
	%	
Finland	–12	84
Korea	–12	–48
Denmark	–6	–17
Japan	–10	–2
Sweden	–5	–12
Norway	–1	40
Hungary	–7	–10
Poland	–11	–16
Czech Republic	–4	13
Italy	–15	–6
Germany	1	–8
Canada	–4	0
France	2	–10
Turkey	–5	13
Slovak Republic	–5	8
Portugal	–23	61
Spain	–8	6
Belgium	8	–4
EU15	**–6**	**–3**
Luxembourg	10	–6
Netherlands	3	–8
Greece	14	–12
United States	–6	–2
Austria	–4	–2
OECD	**–4**	**–3**
United Kingdom	–24	–2
Switzerland	2	–5
Mexico	5	3
Australia	3	–6
Ireland	–9	0
Iceland	9	–3
New Zealand	54	–4

StatLink http://dx.doi.org/10.1787/288135336056

1. Other land includes: Fallow and other agricultural land.
2. For Austria other land data are 0.6%; Denmark other land data are 2.6%; Netherlands other land data are 0.4% and Switzerland other land is 0.8%.

Source: FAOSTAT (2006); national data for Austria, Belgium, Canada, the Czech Republic, Denmark, France, Germany, Hungary, Iceland, Ireland, Japan, Korea, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain and Turkey.

for cultivation of arable and permanent crops (*e.g.* **Mexico**). For some types of semi-natural agricultural habitats (*i.e.* farm woodland), however, the area has increased (notably in **Portugal** and the **United States**) or remained stable over the past decade (Table 1.8.4). The change in the area under fallow has revealed a mixed picture over the past 12 years, increasing for some countries but decreasing for others (Table 1.8.5). But there is little information on whether this land is green or bare fallow and for how long it has remained as fallow and, hence, makes it difficult to interpret the likely impacts on wild species.

Table 1.8.4. **Share of farm woodland in agricultural land area**

	Farm woodland area (000 ha)		Share of farm woodland in total agricultural land area (%)	
	1990	2002	1990	2002
Belgium[1]	0.3	0.1	0.02	0.01
Denmark[2]	92	112	3.3	4.2
Italy[3]	626	293	3.5	1.9
Portugal[4]	966	997	24.2	26.3
Spain	3 906	4 410	12.8	15.0
United States[5]	138 265	139 757	32.4	34.1

StatLink http://dx.doi.org/10.1787/301562512202

1. For Belgium the value equals –0.01, data for 1990-92 and 2000, only for Flanders.
2. Data for 1990 and 1998.
3. Data for 1995 and 2003.
4. Data for 1990 and 2000 do not include wooded pasture land.
5. Data for 1992 and 1997 (hedges and woodlands: other forest use land).

Source: OECD Agri-environmental Indicators Questionnaires, unpublished; FAOSTAT (2006), national data for Portugal and Spain.

Table 1.8.5. **Share of farm fallow in agricultural land area**

	Farm fallow land area (000 ha)		Share of farm fallow land in total agricultural land (%)	
	1990	2002	1990	2002
Austria	21	106	0.6	3.2
Belgium[1]	0	6	0.0	0.4
Canada	7 921	4 680	12.7	8.1
Czech Republic[2]	3	71	0.1	1.7
Denmark[3]	250	225	9.0	8.4
Finland	183	210	7.1	9.4
France[4]	236	1 072	0.8	3.6
Germany[5]	780	848	4.4	5.0
Greece[6]	501	441	5.8	5.2
Italy[7]	3 958	3 666	21.9	23.9
Luxembourg	0	2	0.2	1.5
Netherlands[8]	6	28	0.3	1.4
Norway	4	2	0.4	0.2
Portugal[9]	1 159	577	29.1	15.2
Spain	3 696	4 297	12.1	14.6
Sweden	176	269	5.2	8.5
Switzerland	3	4	0.2	0.3
Turkey	5 324	5 040	12.7	12.2

StatLink http://dx.doi.org/10.1787/301624765841

1. Data for 1990-92 and 2000 refer only to Flanders.
2. Data for 1990 and 2000.
3. Data for 1995 and 2002.
4. Data for 1990 and 2003.
5. Data for 1991 and 2001.
6. Data for 1990 and 2000.
7. Data for 1995 and 2003.
8. In 2002: 5 709 ha "black fallow/set aside", excluding "catchcrop/green fertiliser crops" (= 15 000 ha) according to LEI-CBS (agricultural statistics).
9. Data for 1990 and 2000.

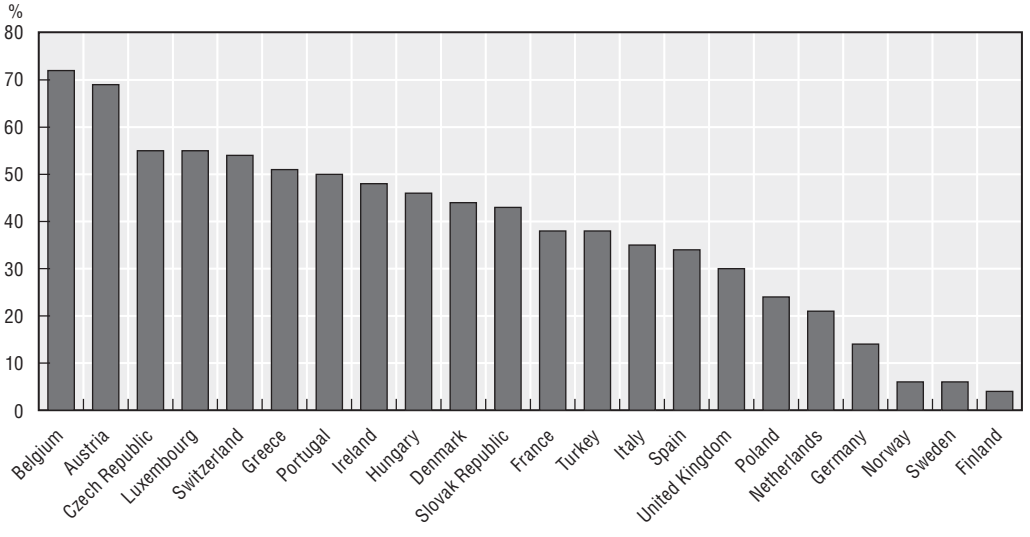
Source: OECD Agri-environmental Indicators Questionnaire, unpublished; FAOSTAT (2006); national data for Norway, Portugal and Spain.

Interpreting the biodiversity impacts of these changes in agricultural semi-natural areas is complex. On the one hand there has been an overall conversion to other land uses (mainly forestry), while on the other hand some arable land has been converted to permanent pasture or farm woodlands. In addition, the fragmentation of habitats arising from changes in farmland use is also reported to have a harmful impact on biodiversity (*e.g.* **Belgium**). Moreover, in some countries the reduction in area of certain low intensity agro-ecosystems developed over hundreds of years, which are key habitats for flora and fauna (*e.g.* low intensity rice paddies in **Japan** and **Korea**; alpine pasture in **France**; and low intensity meadows in **Norway, Sweden** and **Switzerland**, see Chapter 3), is also considered to be detrimental to biodiversity. However, some countries have introduced programmes to maintain semi-natural habitats (Chapter 3).

For many OECD countries agriculture accounted for a major share of the harmful impacts affecting the quality of Important Bird Areas (IBA) in the late 1990s, through practices which have caused a greater intensification of farming (Figure 1.8.12). However, for **Finland, Germany, Japan, Korea, Norway** and **Sweden**, other factors are more important than agriculture, for example the harmful impacts of afforestation, urbanisation, recreation and tourism. However, the conversion of agricultural land use to other uses has had an important impact on reducing the habitat quality of IBAs, especially in marginal extensive farming areas, having had a notable impact in **Austria, Denmark** and **Sweden** (Heath and Evans, 2000).

Figure 1.8.12. **Share of national Important Bird Areas where intensive agricultural practices pose a serious threat or a high impact on the areas' ecological functions**

Late 1990s



StatLink http://dx.doi.org/10.1787/288140273812

Source: BirdLife International (2004).

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1.9. FARM MANAGEMENT

KEY TRENDS

A growing number of OECD farmers are adopting environmental farm management practices as a result of voluntary private led initiatives intended to respond to consumer concerns, including those from food processors and retailers (*e.g.* pesticide management), and government incentives provided through payments and regulations. But only around a third to a half of OECD member countries are regularly monitoring changes in environmental farm management practices, with the notable exception of organic management where all countries are tracking changes in this indicator.

The adoption of nutrient management practices (NMPs) is widespread across OECD countries, with an increase in their uptake over the period 1990-2004, for around half of the OECD countries monitoring NMPs. For countries with a high and increasing uptake of NMPs they have usually experienced a reduction in nutrient surpluses (Belgium, Czech Republic, Denmark, Finland, Germany, the Netherlands, Norway, Sweden, Switzerland), but for countries where nutrient surpluses have risen or are well above the OECD average (in terms of kg nutrients per hectare of farmland) (Canada, Ireland, Japan, Korea and New Zealand), NMP adoption rates are generally lower, although increasing in Canada and Korea.

Despite the increase in adoption of ***environmental integrated pest management practices (IPM)***, the level of uptake across OECD countries is modest, although only about a third of OECD countries track IPM. But for countries with a high IPM uptake or growth in organic farming they have also experienced a decrease in pesticide use (Austria, Czech Republic, Denmark, Finland, Germany, Norway, Sweden, Switzerland, United Kingdom and the United States).

The area of farm land under soil management practices (SMPs) has remained stable over the past decade, but only a third of OECD countries monitor changes in SMPs. Where the rate of SMP adoption has risen (Canada, United States), this has led to reduced soil erosion risks and greater provision of feed for wild species, although where SMP uptake rates are low, soil degradation problems remain (Hungary, Italy, Korea, Slovak Republic and Turkey).

OECD countries, where water management for irrigation is important, are often applying inefficient water conservation technologies. Uptake of the most efficient drip emitter water conservation technology is over 20% of the total irrigated area for only a few countries (Czech Republic, Greece, Italy, Spain), but for other countries where irrigated agriculture is significant and the competition for water resources more intense the uptake of drip emitters is lower (Australia, France, Turkey, United States), although for Australia, France and the United States there is widespread use of low-pressure sprinklers.

The OECD share of agricultural land under biodiversity management plans is under 10% for most countries, except Austria, Ireland and Switzerland, although only a third of OECD countries monitor biodiversity management. But many countries are just beginning to implement agri-biodiversity management plans as part of national biodiversity strategies, linked to commitments under the *Convention of Biological Diversity*.

The OECD area under certified organic farming has increased substantially between the early 1990s to 2004, even so it accounted for less than 2% of total farmland by 2002-04. However, the share is higher in most European countries (around 6% or higher in Austria, Denmark, Finland, Italy, Sweden and Switzerland) but much lower in mainly non-European OECD countries (under 1% in Canada, Japan, Korea, Mexico, New Zealand and the United States).

Indicator definitions:

Nutrient management

- Number (area) of farms (agricultural land area) under nutrient management plans.
- Share of farms using soil nutrient testing (agricultural land regularly sampled and analysed for nutrient content).

Pest management

- Arable and permanent crop area under integrated pest management.

Soil management

- Arable land area under soil conservation practices.
- Agricultural land area under vegetative cover all year.

Water management

- Irrigated land area using different irrigation technology systems.

Biodiversity management

- Agricultural land area under biodiversity management plans.

Organic management

- Agricultural land area under certified organic farm management (or in the process of conversion to an organic system).

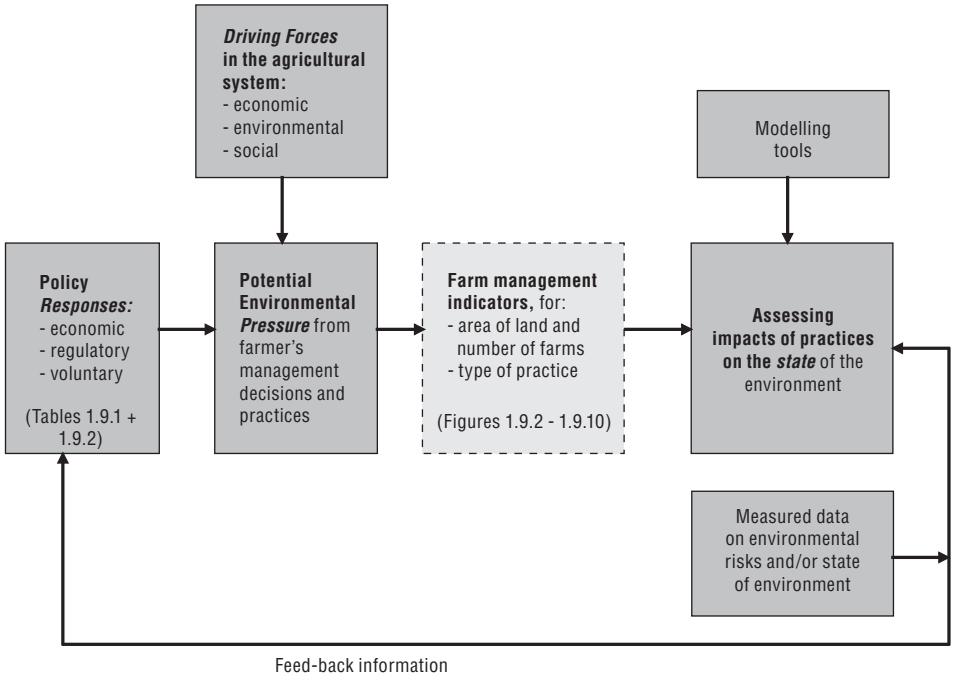
Concepts and interpretation

This final section of Chapter 1 highlights the linkages between the previous sections on agri-environmental ***driving forces*** (*i.e.* nutrient and pesticide use, energy consumption, and water use), the ***state*** of the environment as it relates to agriculture covering soil, water and air quality, and biodiversity, and the ***response*** to improve agriculture's environmental performance in terms of changes in farming practices and systems (Figure 1.9.1). The linkages between farm management indicators (FMIs) and other drivers and environmental outcomes associated with farming systems are highlighted in Figure II.1 in the *Background and Scope of the Report*, Section II, drawing on the Driving Force-State-Response Framework (DSR).

FMIs can provide an early indication of likely changes in the direction of environmental impacts sometimes before they can be measured by other indicators, such as those pertaining to soil and water quality (OECD, 2005a). They can assist farmers and policy makers by informing them of the linkages between farm activities and environmental impacts. FMIs can also serve as a proxy for "state" indicators where measuring actual changes in the environment are difficult or costly. But there is often a time lag, which can be many years, between the implementation of farm management plans and the consequential change in environmental conditions.

FMIs are able to highlight environmental pathways where causal links are known, such as those between nutrient use (*driving force*), nutrient concentrations in water bodies (*state*) and nutrient management practices (*response*). FMIs interpreted in this way may help make them more easily understood by decision makers. In addition, the description of such environmental pathways can help to explain to farmers the need to undertake certain

Figure 1.9.1. **OECD farm management indicator framework**



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Source: OECD Secretariat, adapted from OECD (2005a).

practices to safeguard the environment (OECD, 2005a). FMIs can be organised in terms of a three-tiered approach covering trends in:

- ***farm management practices*** addressing *specific* environmental issues, including: nutrients, pests, soil, water, and biodiversity, which are the indicators covered in this section;
- ***environmental farm management plans*** covering the entire range of farming systems from integrated "conventional" farming to organic operations, as well as specialised crop and livestock farming systems. Indicators of environmental farm management plans are only partially covered in this section, through organic farming, but background information is provided on the range of specific practices that countries are adopting as part of a broader environmental farm planning approach; and
- ***farm management capacity*** *revealing* impediments and incentives affecting the adoption of farming practices that can enhance agricultural sustainability, covering investment in the sector's capacity to improve farmers' education, farm incomes, research, farm advisory expenditure and the social institutions supporting farmers. It is beyond the scope of this report to cover these issues, but some limited discussion is provided on the incentives that OECD countries are providing to farmers to adopt a range of environmental farm management practices (also see Chapter 2).

Data availability is the main barrier to wider coverage of FMIs, as many OECD countries do not have information on the extent to which environmental management practices are adopted. But many countries are beginning to undertake surveys to measure the extent and characteristics of management practices, for example, in **Australia, Canada**, the **EU15** and the **United States**. A further limitation in measuring FMIs concerns definitional problems. Central concepts, such as environmental farm management plans,

integrated pesticide management and organic management, need greater consistency in definitions. Nevertheless, it should be stressed that farm management practices will vary within and across countries, even when addressing the same issue, such as pest control, reflecting differences in farming systems, agro-ecological and climatic conditions.

Recent trends

1.9.1. Overview of environmental farm management

A growing number of OECD farmers are adopting environmental farm management practices (EFMPs), especially since the mid-1990s. But EFMP uptake varies across countries in terms of both the type and extent of practice adopted (Table 1.9.1). Also the national focus of EFMPs usually reflects the varying agro-ecosystems and environmental priorities across countries, for example, soil conservation in **Canada** and the **United States**, irrigation management in **Australia** and **Spain**, and nutrient management across **EU15** countries (Table 1.9.1). Many countries do not have precise information on the number (or area) of farms with EFMPs but provide descriptions of the characteristics of these practices. Moreover, only around a third to a half of OECD member countries are regularly monitoring changes in environmental farm management practices, with the notable exception of organic management where all countries are tracking changes in this indicator.

For most countries farmer incentives to adopt EFMPs are mainly provided through voluntary led and private sector initiatives, although incentives through a combination of government support payments and regulations are also important, with in many cases EFMPs regularly audited (Table 1.9.2). Financial support can be provided, for example, to cover the capital costs of installing manure storage facilities, while regulations enforced by fines are used to compel adoption of certain practices, such as limiting air polluting emissions (OECD, 2003a; 2004; 2005b). Voluntary initiatives used to encourage EFMP uptake can be led by (OECD, 2005a): farmers (*e.g.* **New Zealand**'s "Project Green" for livestock); the farm input supply industry (*e.g.* International Fertilizer Industry Association); food processors (*e.g.* Sustainable Agriculture Initiative Program); and food retailers (*e.g.* supermarket chains, such as Tesco's "Nature's Choice" United Kingdom standards).

1.9.2. Nutrient management

The adoption of nutrient management plans (NMPs) is widespread across OECD countries, with a notable increase over the period 1990 to 2004, although only around half of OECD countries monitor NMPs (Figures 1.9.2, 1.9.3 and 1.9.4). Some countries, however, have maintained a very high uptake rate of NMPs throughout the past decade (**Belgium, Czech Republic, Denmark, Finland, Germany, Norway**), while for some others NMP adoption rates have grown rapidly (the **Netherlands, Switzerland**). All these countries have experienced a reduction in nutrient surpluses over the 1990s. Equally, in countries, such as **Canada, Ireland, Japan, Korea** and **New Zealand** where nutrient surpluses have been increasing or are well above the OECD average (in terms of kg nutrients per hectare of farmland), NMP adoption rates are generally at a low share of total farm numbers (or farmed area), although soil nutrient testing is becoming more widespread in **Canada** and **Korea** (Figure 1.9.4).

Table 1.9.1. **Countries recording adoption of environmental farm management practices**

Late 1990s-early 2000s

Environmental farm management type and practices	Total OECD[1]	Australia[2]	Austria	Belgium[3]	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Japan	Korea	Luxembourg	Netherlands	New Zealand	Norway	Portugal	Slovak Republic	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States[4]
Nutrient management plan practices																												
Voluntary codes of practice	11		X			X			X			X	X		X	X		X	X		X	X		X	X			X
Obligatory codes of practice	9		X	X		X		X	X			X			X			X	X	X	X			X				X
Restriction of fertiliser application	17		X	X		X	X[5]	X	X	X[5]		X	X	X[5]		X		X	X	X	X	X		X	X		X[5]	X
Conditions for nutrient application near water	15		X	X		X		X[5]	X[5]			X	X	X[5]		X		X	X	X	X			X	X		X[5]	
Cover crops used to prevent nutrient run-off	19		X	X		X	X[5]	X	X	X	X	X		X[5]		X		X	X	X	X[5]		X[5]	X[5]	X	X	X[5]	X
Use of legumes in crop rotation	8		X			X										X			X	X		X		X				X
Soil test	14	X	X	X	X	X		X	X			X	X			X			X	X	X	X		X	X			X
Records of fertiliser use	12			X		X		X	X			X	X			X		X	X	X	X	X		X	X			X
Split fertiliser applications are used	10		X	X		X		X	X			X				X			X	X	X	X		X	X			X
Farm nutrient balance calculated regularly	11		X	X	X	X		X	X				X			X		X	X	X				X	X			X
Requirements on livestock manure storage facilities	14		X	X		X	X[5]	X[5]	X			X	X		X	X		X	X	X	X	X		X	X			
Non-chemical pest control practices																												
Use of soil tillage	12		X	X	X							X	X			X		X		X	X		X	X	X			X
Use of crop rotations	12		X	X	X							X	X			X		X		X	X		X	X	X			X
Biological control methods	13		X	X	X							X	X		X	X		X		X	X		X	X	X			X
Use of pheromones	12		X	X	X							X			X	X		X		X	X		X	X	X			X
Pruning, hand weeding, canopy management	12		X	X	X							X	X		X	X		X		X			X	X	X			
Crop residue destruction	10		X	X	X							X	X			X		X		X	X			X	X			
Professional scouting	9		X	X	X							X						X		X				X	X			X
Strategic locations and planting times	11		X	X	X							X	X			X		X		X	X			X	X			X
No method but pesticide not applied	7		X		X							X			X			X		X	X			X				

Table 1.9.1. **Countries recording adoption of environmental farm management practices** *(cont.)*

Late 1990s-early 2000s

Environmental farm management type and practices	Total OECD[1]	Australia[2]	Austria	Belgium[3]	Canada	Czech Republic	Denmark	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Japan	Korea	Luxembourg	Netherlands	New Zealand	Norway	Portugal	Slovak Republic	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States[4]
Soil conservation management practices																												
Conservation tillage	24	X	X	X	X	X	X[5]	X[5]	X[5]	X[5]	X	X	X	X[5]	X	X	X[5]		X	X	X[5]	X	X[5]	X[5]	X		X[5]	X
Zero tillage	10			X	X	X						X			X	X			X	X	X	X			X			X
Crop rotations	10		X	X	X							X			X	X			X	X	X	X			X			X
Winter cover crops	10			X	X				X						X	X			X	X	X	X		X	X			X
Contour cultivation	4		X	X															X	X	X	X						
Grassed waterways	6		X	X	X														X	X				X				X
Strip-cropping	4		X	X	X											X												X
Windbreak	9		X	X	X							X			X	X			X	X	X	X			X			
Irrigation management practices																												
Flooding	7	X		X	X				X		X										X		X			X		X
High pressure rainguns	12	X		X	X	X			X				X					X			X	X		X		X	X	X
Low pressure sprinklers	10	X		X	X				X		X		X					X			X		X				X	X
Drip-emitters	11	X		X	X	X			X		X		X					X			X		X			X		X

StatLink http://dx.doi.org/10.1787/301763453364

1. Total number of OECD countries adopting a specified farm management practice.
2. Data are taken from Australian Bureau of Statistics, (2005).
3. Presents data for Flanders and Wallonia; for Wallonia nutrient management plan characteristics are obligatory for farms where the Basic Soil link Rate (BSL) is > 1; only Wallonia indicates split fertiliser application; all soil conservation management practice data presents only Wallonia apart from winter cover crops which represents Flanders and Wallonia; high-pressure raingun practice is only applied in Flanders.
4. Data are taken from USDA (2001), (2004).
5. Data are taken from EEA (2005).

Source: Australian Bureau of Statistics (2005); EEA (European Environment Agency), (2005); OECD Agri-environmental Indicators Questionnaire, unpublished; United States Department of Agriculture (2001).

Table 1.9.2. **Overview of farmer incentives to adopt environmental farm management practices**

Late 1990s-early 2000s

	Nutrient								Pests								Soil								Water								Biodiversity and landscape								Environmental farm plans							
	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII
Australia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Austria[1]	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X
Belgium[2]	..	..	..	..	X	..	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X
Canada	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Czech Republic	..	..	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Denmark	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Finland	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
France	..	..	..	..	X	..	X	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X	..	X	X	X	X	X	X	X	X	..	X	..	X	X	..	..	X	X
Germany[3]	..	..	..	..	..	..	X	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	X	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Greece	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hungary	..	..	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	..	..	..	..	..	..	..
Iceland	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ireland[4]	..	..	..	..	X	X	..	X	X	..	..	..	..	..	..	..	X	..	..	..	..	..	..	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	X	X	..	X	..	..	..	..	X	..	..
Italy	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Japan	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Korea[5]	X	..	..	..	X	X	X	X	X	..	..	..	X	..	X	X	..	..	..	..	X	..	..	X	X	..	..	..	X	..	..	..	X	..	X	..	..	X	X	..	..	X	..	X	X	X	X	X	X
Luxembourg	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mexico	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Netherlands[6]	..	..	..	..	..	..	..	X	X	..	..	..	..	X	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	X	..	..	X	..	..	..	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Norway[7]	X	X	X	X	X	..	X	X	X	..	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	..	X	X	X	..	..	..	X	X	X	X	X	X	..	X	X	X	X	X	..	X	X
Poland	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Portugal	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Slovak Republic	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Spain	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Sweden[8]	X	..	X	..	X	X	X	X	X	..	X	..	..	X	X	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	X	X	X	X	X	..	X	X	..	..	..
Switzerland[9]	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	..	..	..	..	X	X	..	X	X	X	X	X	X	..	X

Table 1.9.2. **Overview of farmer incentives to adopt environmental farm management practices** *(cont.)*

Late 1990s-early 2000s

	Nutrient								Pests								Soil								Water								Biodiversity and landscape								Environmental farm plans							
	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII	VIII
Turkey	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
United Kingdom	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
United States	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
OECD	**3**	**1**	**2**	**1**	**8**	**5**	**4**	**8**	**5**	**0**	**2**	**1**	**5**	**5**	**3**	**6**	**2**	**1**	**1**	**1**	**6**	**3**	**2**	**5**	**3**	**0**	**1**	**1**	**6**	**2**	**0**	**3**	**1**	**2**	**1**	**1**	**8**	**6**	**1**	**6**	**4**	**2**	**4**	**4**	**6**	**3**	**2**	**4**
EU15	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .

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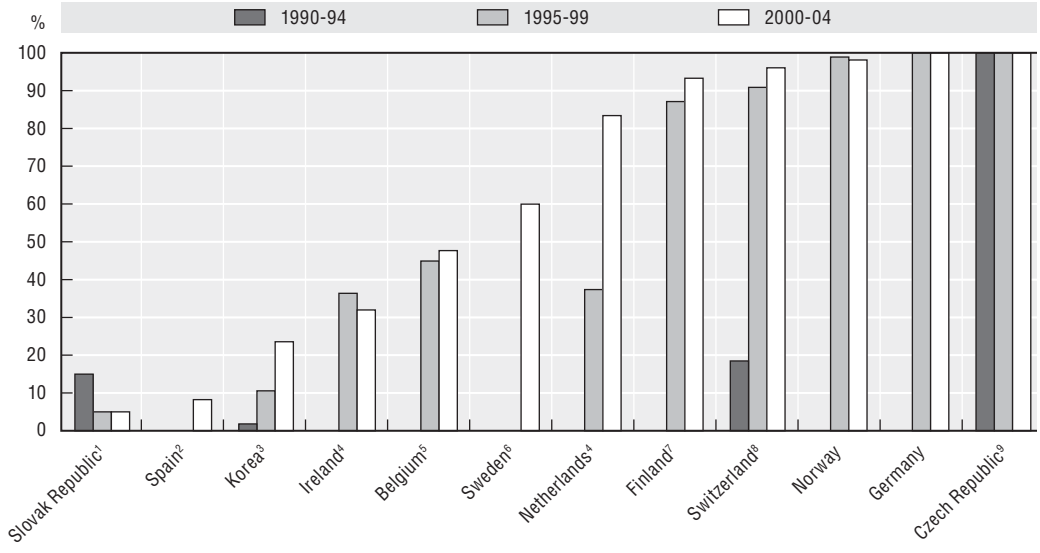
. .: Not available.

Legend: I = farmer-led initiative, II = local community-led initiative, III = promoted by farmers' organisations, IV = promoted by the agro-food industry, V = supported or enforced by government, VI = payment is provided for adopting the practice, VII = practice is obligatory (*i.e.* use of a regulation or standard), VIII = practice is regularly audited.

1. Audit every 3 years.
2. Data presents only Wallonia; for the farm management practices concerning pests, payments are provided for adopting organic farming; farm management practices for soil, biodiversity and landscape are part of the "Framework of Regional Environmental Regulation"; practices for environmental farm plans are indicated as purposed in the new agro-environmental regulation that took place in the end of 2004.
3. Audit every year.
4. Audit every 4 years.
5. Practices that are enforced by the government: nutrients, pests, water = national, soil, biodiversity and landscape, environmental farm plans = national/regional; audit for nutrients, pests, biodiversity and landscape, environmental farm plans: every year, for soil: 2-4 years depending on fields. *Source:* Korea Rural Economic Institute.
6. Audit for nutrients, pests, biodiversity and landscape: every year.
7. Practices that are enforced by the government: nutrients, pests, water = national, soil = national/regional, biodiversity and landscape, environmental farm plans = national/local; for VII pests only for organic farming and VII soil only for some areas; audit every 20 years (*e.g.* every year, 2, 5 years, etc.). Approx. 5% each year (part of a subsidy control).
8. For VIII: diverse programmes and frameworks like "Sweden's 15 environmental quality objectives", agri-environmental programmes on nutrients, pesticides, biodiversity and landscape.
9. Practices that are enforced by the government = national.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

Figure 1.9.2. **Share of agricultural land area under nutrient management plans**



StatLink http://dx.doi.org/10.1787/288180530473

Note: Nutrient management plans cover nitrogen, phosphorus and potassium, unless stated otherwise.

1. Nutrients not specified.
2. Average 2000-04 = average 2001-03.
3. Data include only arable crops and share of arable crop area.
4. Nutrient management plan covers nitrogen and phosphorus.
5. Data include Flanders for 2000-03 (N, P), and Wallonia for 2003 (N).
6. Average 2000-03 = average 2001-04, data cover nitrogen, phosphorus and calcium. Area of farms that get support for a crop management plan including a nutrient management plan.
7. Average for 1995-99 and 2000-04 refer to year 1997 and 2002-04, data covers nitrogen, phosphorus and calcium.
8. Data for the period 1990-94, 1995-99 refer to year 1993, 1999.
9. Nutrient management plan covers nitrogen, phosphorus, potassium, calcium and magnesium.

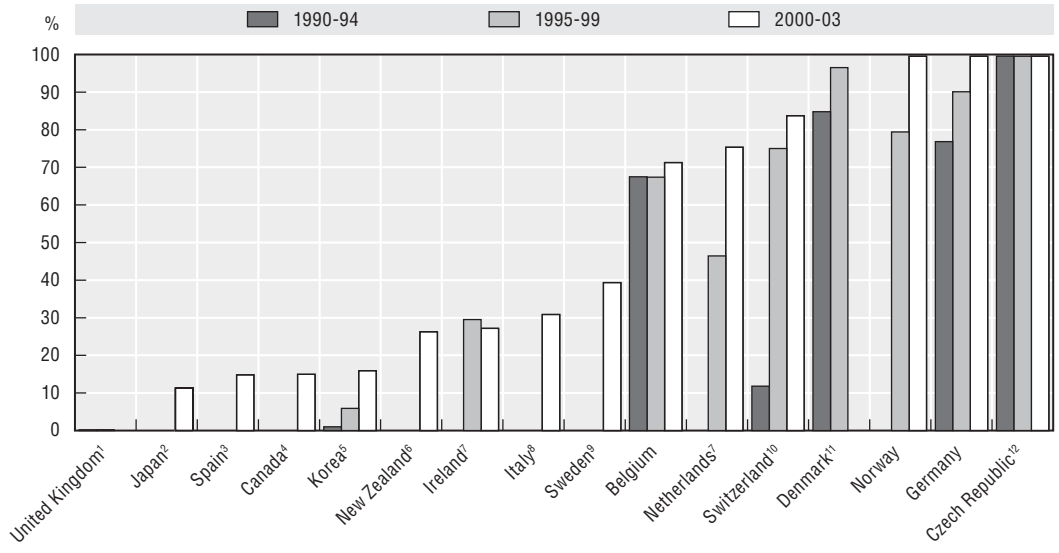
Source: OECD Agri-environmental Indicators Questionnaire, unpublished; national data sources.

In many OECD countries, NMPs are widely supported or enforced by governments, and the plans are regularly audited (Table 1.9.2). For most of these countries NMPs cover a combination of using cover crops to prevent nutrient run-off, soil tests (Figure 1.9.4), recording fertiliser use and nutrient balances, and improving manure storage facilities and livestock housing to reduce nutrient emissions, especially for the pig, poultry and dairy sectors (Table 1.9.1, EEA, 2005; OECD, 2003a; 2004). However, the practice of using legumes in crop rotations seems less widespread (Table 1.9.1). Soil nutrient tests are carried out in almost all OECD countries, with both public and private bodies involved in these tests. Most OECD countries include both nitrogen and phosphorus in soil tests, while some countries test for other soil nutrients and trace elements.

1.9.3. Pest management

Despite the overall increase in adoption of integrated pest management (IPM) practices, the level of uptake is modest, as measured by the share in the farmed area, although only about a third of OECD countries track IPM (Figure 1.9.5). However, the rise in the area under organic farming (Figure 1.9.10) must also be taken into account in this context, as the use of most pesticides are not usually permitted under certified organic farming. Voluntary led initiatives, especially those that are farmer led, are of importance in providing incentives to adopt IPM (Table 1.9.2).

Figure 1.9.3. **Share of total number of farms under nutrient management plans**



StatLink http://dx.doi.org/10.1787/288181521450

Note: Nutrient management plans cover nitrogen, phosphorus and potassium, unless stated otherwise.

1. Data for United Kingdom are 0.2% in 1990-94, 0.2% in 1995-99.
2. Chemical fertilisers only.
3. Nutrients not specified.
4. *Source:* Statistics Canada (2001), Farm Environmental Management Survey.
5. Data include only arable crops.
6. Nutrients covered by the management plan: nitrogen, phosphorus, potassium sulphur, magnesium, and other nutrients.
7. Nutrient management plan covers nitrogen and phosphorus.
8. For 2000 only and plan applies only to inorganic fertiliser.
9. Number of farms that get support for a crop management plan including a nutrient management plan.
10. Data for period 1990-94 and 1995-99 refer to year 1993 and 1999.
11. Data for 1994 and 1995-98.
12. Nutrient management plan covers nitrogen, phosphorus, potassium, calcium and magnesium.

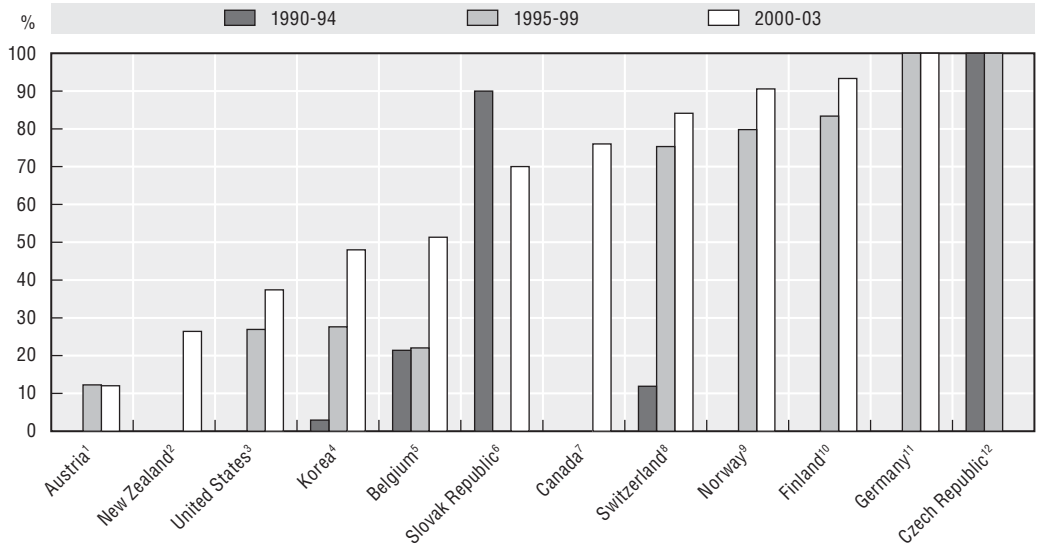
Source: OECD Agri-environmental Indicators Questionnaire, unpublished; OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; national data sources.

For most countries with a high level or increasing uptake of IPM or organic farming (**Austria, Czech Republic, Denmark, Finland, Germany, Norway, Sweden, Switzerland, United Kingdom**) they have also experienced a reduction in pesticide use over the past decade (Section 1.3). In the **United States**, where pesticide use also decreased during the 1990s, there has been an expansion in the area sown to genetically engineered herbicide-tolerant crop varieties (Section 1.8), together with government programmes that encourage IPM uptake (Figure 1.9.5). In **Canada**, a 2001 survey of farm environmental practices found that most pesticides are applied by a certified operator, and that almost half of producers calibrate their sprayers at the beginning of the season, although only 14% re-calibrate spraying equipment before using a different pesticide. The optimal practice is used for the timing of insecticide applications, but some improvements can be made in the timing of herbicide applications (Lefebvre *et al.*, 2005).

1.9.4. Soil management

The area of OECD farm land under soil management practices (SMPs) has remained stable since 1990 for many countries. But in some cases where adoption rates have increased, this has brought benefits in terms of reducing soil erosion risks, though only

Figure 1.9.4. **Share of total number of farms using soil nutrient testing**



StatLink http://dx.doi.org/10.1787/288228567322

Note: Soil nutrient testing covers nitrogen, phosphorus and potassium, unless stated otherwise.

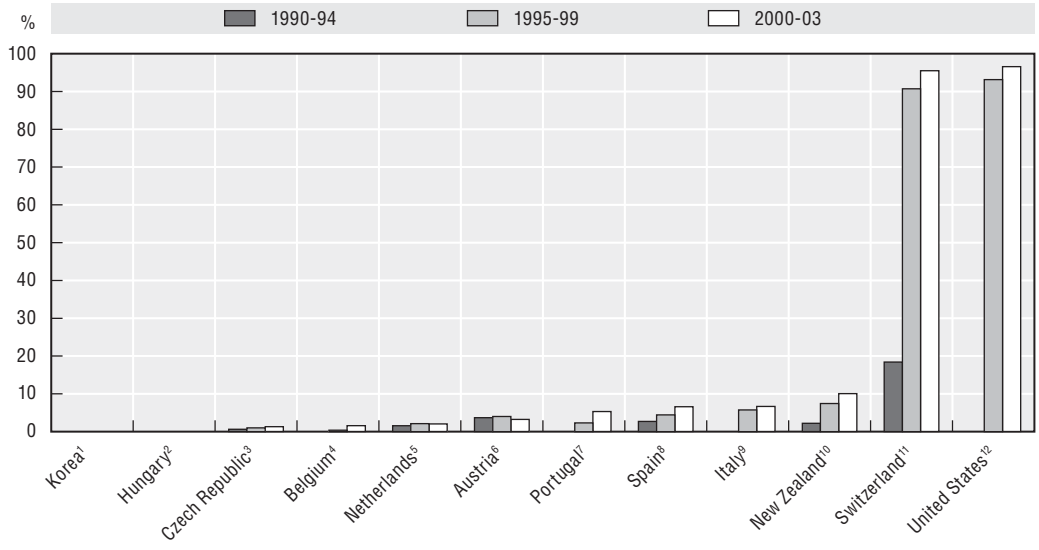
1. Soil tests cover phosphorus and potassium, tests are conducted every 4-5 years.
2. Nutrients covered by the management plan: nitrogen, phosphorus, potassium sulphur, magnesium, and other nutrients. Tests are conducted every 2-3 years; number of farms are estimated by the country.
3. Represents survey data (not directly comparable from year to year) for wheat, cotton, maize and sorghum.
4. Tests were conducted in 1993 every 2-3 years and in 1997 and 2002 every year.
5. Soil test covers phosphorus, potassium, magnesium, calcium and sodium for Flanders and nitrogen, potassium and phosphorus for Wallonia, the standard test for Flanders does not include nitrogen, nitrogen is tested in the N-index which is not shown here but is available for the same years; data include 2000-03 value of Flanders and 2003 value of Wallonia.
6. Data for the period 1990-94 refer to 1985-89.
7. Data represent farms with sales > USD 10 000, with nutrient tests every year up to every 5 years or more.
8. Data for the period 1990-94 and 1995-99 refer to year 1993 and 1999.
9. Soil tests cover phosphorus, potassium, magnesium and calcium. Nitrogen tests are conducted in spring, but the number of farms for nitrogen are not given. Soil tests are mostly conducted every 5-8 years.
10. Soil tests cover nitrogen, phosphorus, potassium, calcium and magnesium, tests are conducted every 4-5 years.
11. Tests are conducted every year, phosphorus and potassium tests are conducted after more than 5 years.
12. Soil test covers phosphorus, potassium, calcium and magnesium, tests are conducted every 3 and 6 years, respectively.

Source: OECD Agri-environmental Indicator Questionnaire, unpublished; OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; national data sources.

around a third of OECD countries are monitoring changes in SMPs (Figures 1.9.6 and 1.9.7). Countries are using a range of practices to help improve soil conservation (Table 1.9.1), although key amongst these are moving towards no-till or conservation tillage and, to a lesser extent an increase in soil vegetative cover, especially using green cover over winter months rather than leaving bare soil (Figure 1.9.7). These practices can also bring benefits to wild species by providing winter feed (Section 1.8). For some countries soil conservation efforts are mainly focused on arable crop areas (*e.g.* **Canada, United States**), but for others a very high share of the entire agricultural area is under SMPs (*e.g.* **Austria, Belgium, Norway, Switzerland**). Most SMPs are supported or enforced by government, with few SMPs farmer led initiatives or promoted by the agro-food industry (Table 1.9.2).

Where improvements in reducing soil erosion rates have been greatest, such as in **Canada** and the **United States** (Section 1.5), this has been associated with an increase in the area or relatively high share of arable land under soil management practices, notably greater use of low till/conservation tillage and an increase in soil green cover

Figure 1.9.5. **Share of total arable and permanent crop area under integrated pest management**



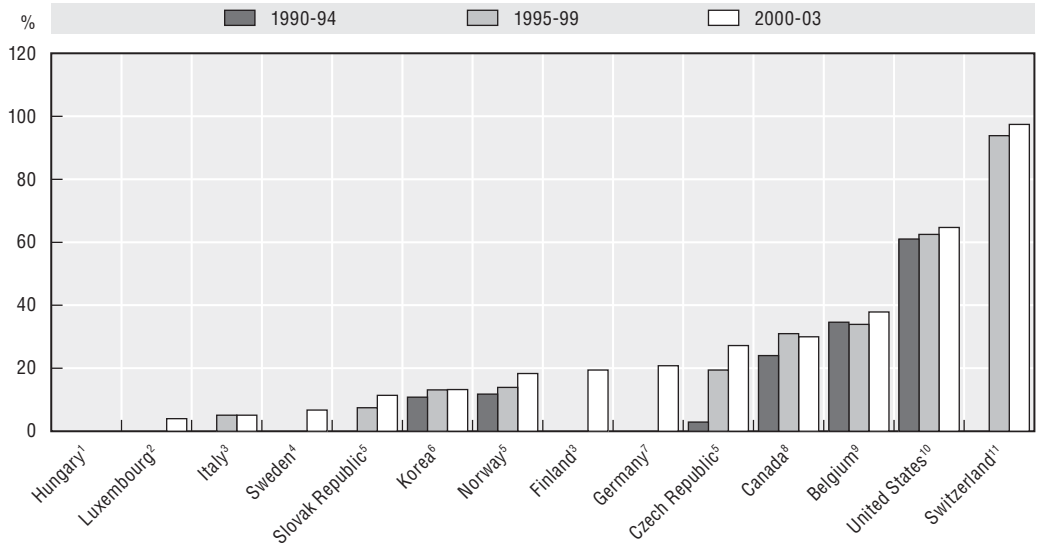
StatLink http://dx.doi.org/10.1787/288258134111

1. Values are 0.17% for 1995-99 and 0.02% for 2000-03. Data for 1995-99 are for 1998, taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France. Data include only crop area.
2. Value for 2000-03 is 0.13%, for other years n.a., data includes total agricultural area and share of total agricultural area.
3. Values are 0.6%, 1990, 1.0% for 1994 and 1.3% for 2003.
4. Data refer to Flanders and Wallonia, data for Flanders include only permanent crops, data for Wallonia include arable and permanent crops; data for 1996 represent the sum of 1996 for Flanders and 1998 for Wallonia. Values are 0.38% for 1995-99 and 1.54% for 2000-03.
5. Arable area and permanent crops (only fruit) with environmental certificate.
6. Values are 3.7% 1995, 4% 1999 and 3.2% for 2000-03.
7. Values are 0.09%, 1995, 2.3% for 1999 and 5.3% for 2002.
8. Data represent only cultivated crops.
9. Values represent data for 1995, 1999 and 2002.
10. Data show values for 1990-94 which include permanent crops (*e.g.* kiwifruit), for 1995-99 which include vegetable crops (*e.g.* outdoor tomatoes) and permanent crops (*e.g.* kiwifruit, winegrapes, apples), and for 2000-03 which include vegetable crops (*e.g.* outdoor tomatoes, brassicas, potatoes) and permanent crops (*e.g.* kiwifruit, winegrapes, apples, avocados, persimmons and stonefruit). Values are 2.21% for 1990-94, 7.45% for 1995-99 and 10.05% for 2000-03.
11. Data for the periods 1990-94, 1995-99 and 2000-03 refer to years 1993, 1999 and 2003.
12. Data from Survey data (not directly comparable from year to year) for wheat, cotton, maize and soyabeans.

Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; OECD Agri-environmental Indicators Questionnaire, unpublished; national data sources.

(Figures 1.9.6 and 1.9.7). In other countries, such as the **Czech** and **Slovak Republics**, the relatively low uptake of soil management practices may be aggravating soil erosion risks (Section 1.5). The poor uptake of soil conservation practices where soil erosion remains an important agri-environmental issue is also reported for **Hungary, Italy, Korea, Slovak Republic** and **Turkey** (Section 1.5 and Chapter 3).

Figure 1.9.6. **Share of arable crop area under soil conservation practices**



StatLink http://dx.doi.org/10.1787/288265066700

1. Value for 2000-03 is 0.1%, other years not available, includes total agricultural land and share of total agricultural land.
2. National data. Value for 2000-03 is 4%.
3. Includes total agricultural land and share of total agricultural land.
4. Data include arable crops (*e.g.* catchcrops, postponed autumn tillage and protection zones).
5. Data include only arable crops.
6. Data include permanent crops and pasture and share of permanent crops and pasture.
7. Data include only arable crops, data refer to 2003/04.
8. Share of cropland area in conservation tillage practices (%).
9. Data includes arable crops (*e.g.* winter wheat and barley for all years and green cover in winter for 1995 and 2000) for Flanders; the 1990-94 value is the sum of 1990 data for Flanders and 1994 data for Wallonia, the 1995-99 value is the sum of 1995 data for Flanders and 1999 data for Wallonia, the 2000-03 value is the sum of 2000 data for Flanders and 2003 data for Wallonia.
10. Data from USDA (2004), data for the period 1990-94 equal 1994; data represent cropland under crop residue management (*e.g.* no-till, conservation management) in US major agriculture productive areas.
11. Data for the period 1995-99 refer to year 1999. Data not available for the period 1990-94.

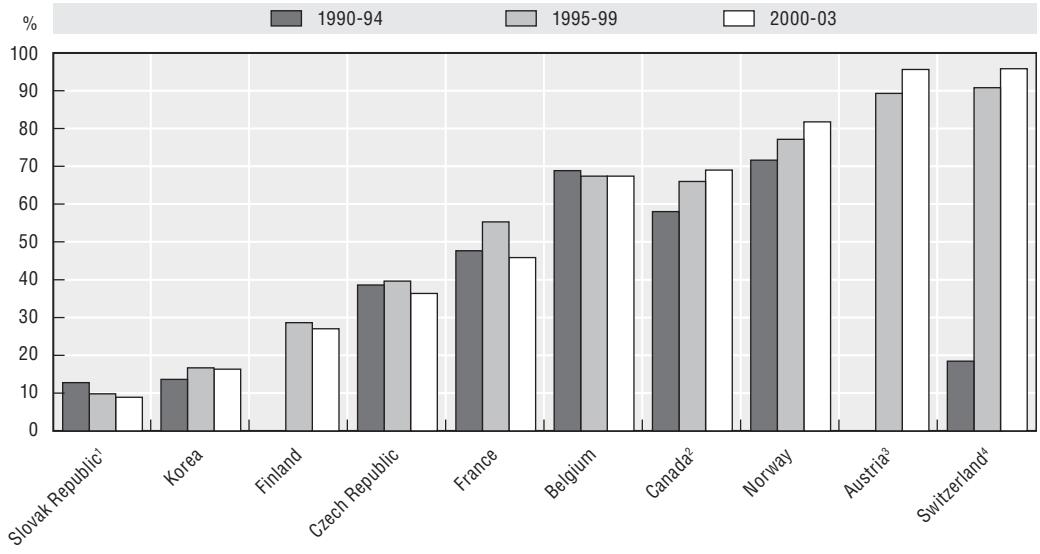
Source: USDA (2004); OECD Agri-environmental Indicators Questionnaire, unpublished.

1.9.5. Water management

For those OECD countries where irrigated agriculture is important, they are generally applying irrigation technologies that are poor in terms of water conservation (Figure 1.9.8). Crop irrigation in most countries involves flooding or high pressure raingun technologies, which use considerably greater quantities of water than the more efficient low pressure sprinklers and drip emitters. As in common with many other EFMPs water management practices are typically supported by government, but rarely obligatory or promoted voluntarily (Table 1.9.2).

The uptake of more efficient water management technologies (*i.e.* drip emitters) covers over 20% of the total irrigated area for only a few countries (**Czech Republic, Greece, Italy, Spain**). But for certain countries where irrigated agriculture contributes an important share in total agricultural output and value, and the pressure to conserve water resources is high in certain regions, the share of the more efficient drip emitter water application technology in irrigated areas is under 10% for **Australia, France, Turkey**, and the **United States**. However, for **Australia, France** and the **United States** there is more widespread use of low-pressure sprinklers (Figure 1.9.8).

Figure 1.9.7. **Share of total arable and permanent crop area under all-year vegetative cover**



StatLink http://dx.doi.org/10.1787/288274883027

1. Data for the period 1990-94, 1995-99 and 2000-03 refer to the year 1992 (12.8%), 1997 (9.8%) and 2002 (8.9%).
2. The percentages show the share of Cropland in Different Soil Cover Classes (%).The percentages shown include the following soil cover classes: very high (≥ 325 days coverage), high (300-324 days coverage) and moderate (275-299 days coverage).
3. Data for the period 1995-99 refer to the year 1999, and for 2000-03 refer to the year 2003.
4. Data for the period 1990-94, 1995-99 refer to year 1993 and 1999.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished; Lefebvre *et al.* (2005); national data sources.

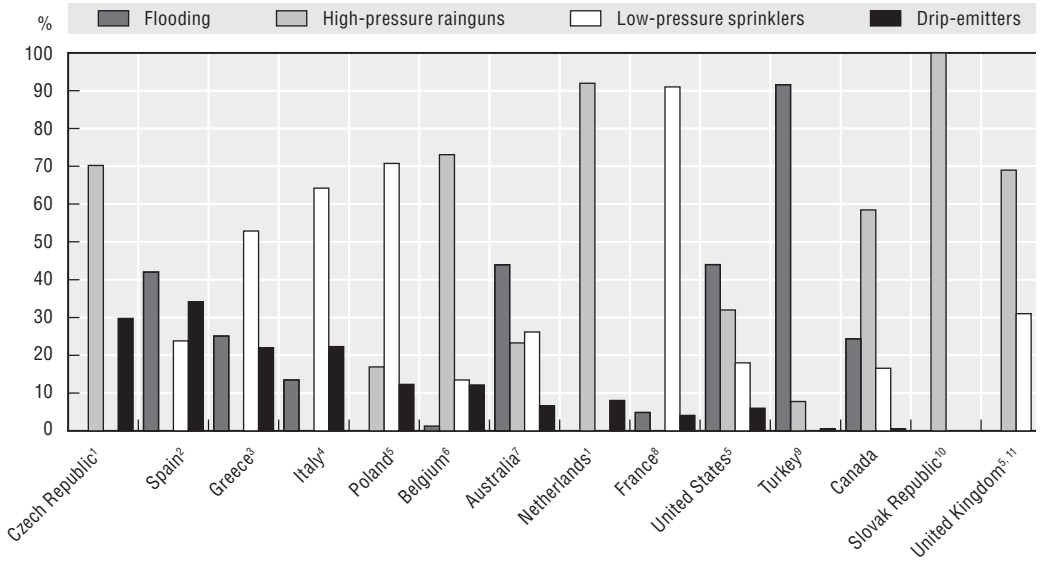
1.9.6. Biodiversity management

The share of agricultural land under biodiversity management plans (BMPs) is low for most OECD countries, except for **Austria, Ireland, Sweden** and **Switzerland** (Figure 1.9.9), although this conclusion should be treated with caution. Most countries are just beginning, or are in the process, of implementing biodiversity management plans in agriculture as part of their broader biodiversity action plans developed under the national implementation of the *Convention of Biological Diversity* (Section 1.8). In addition, many countries are only just starting to monitor the uptake by farmers of biodiversity management plans (about a third of OECD countries in 2003), which in many cases are supported or enforced by governments and regularly audited (Table 1.9.2).

Information on the characteristics of BMPs is currently lacking, but in some cases they cover, for example, conservation of endangered species (Section 1.8) and practices aimed at establishing and managing field margins and riparian buffers. As biodiversity and landscape management practices can be closely linked, it can be difficult to separate the two in a number of countries, such as in many European OECD countries.

Figure 1.9.8. **Share of irrigated land area using different irrigation technology systems**

2000-03



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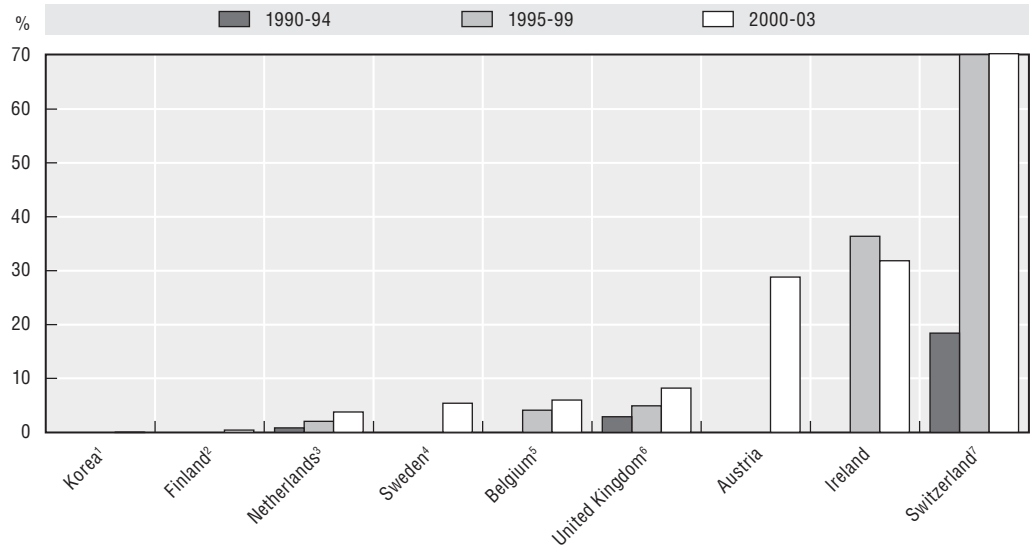
1. Data for 2003.
2. The data are for 2002-03 and represent the area for flooding, sprinklers and drip emitters that are irrigable but not necessarily irrigated.
3. Data for 1999, which show different irrigation technologies' share of total irrigation water use.
4. Data for 2000.
5. National data.
6. Data for Flanders refer to 2002. Flooding data include Wallonia and Flanders data, but for Flanders only ornamental plant cultivation in greenhouses are included; high-pressure raingun data refer only to Flanders; data for low-pressure sprinklers and drip emitters are the sum of Flanders and Wallonia data.
7. Data are taken from the Australian Bureau of Statistics (2005), Irrigation Methods 2002-03; flooding refers to surface, low-pressure sprinklers refer to microspray, drip-emitters refers to drip or trickle, and high-pressure rainguns refers to portable irrigators, hose irrigators, large mobile machines and solid set.
8. Values are an average of data for 2000 and 2003.
9. Data for 2000, value for high-pressure rainguns include area irrigated by low-pressure sprinklers.
10. Data for 2000-03.
11. Data for England.

Source: Australian Bureau of Statistics (2005); OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France, OECD Agri-environmental Indicators Questionnaire, unpublished.

1.9.7. Organic management

The OECD area under certified organic farming has increased substantially, especially since 1993-95, but accounted for less than 2% of total OECD farmland by 2002-04 (Figure 1.9.10). However, there is considerable variation in the importance of organic farming across countries, with the share in the total agricultural area higher in OECD European countries (*e.g.* around 6% or higher in **Austria, Denmark, Finland, Italy** and **Switzerland**) but much lower in non-European OECD countries (*e.g.* under 1% in **Canada, Japan, Korea, Mexico, New Zealand** and the **United States**), except notably **Australia** where it is over 2%, and in **Greece, Iceland, Ireland, Poland** and **Turkey** where it is also very low.

Figure 1.9.9. **Share of agricultural land area under biodiversity management plans**



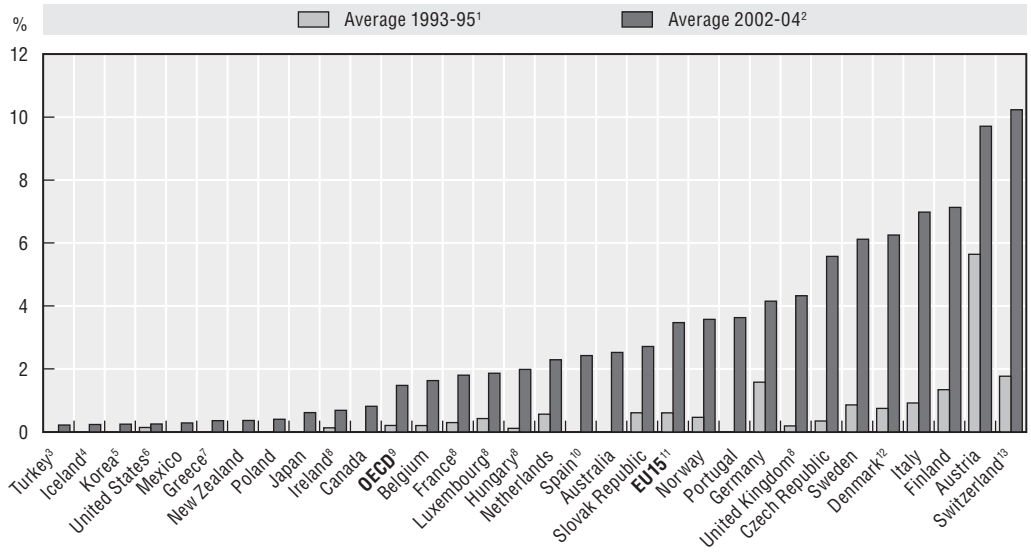
StatLink http://dx.doi.org/10.1787/288303510537

1. Value is 0.02% for 2000-03, data for other years are not available.
2. Value for 2000-03 is 0.42%, other years are not available.
3. Value for 1990-94 is 0.8%, data for 2003 are an estimate by the Netherlands.
4. Data include only pasture and share of pasture area.
5. Data represent Flanders and Wallonia; value of 2001 is the sum of Flanders (2001) and Wallonia (2003).
6. Includes area under the "Wildlife Enhancement Scheme" and "Agri-environment Schemes".
7. Data for the period 1990-94 and 1995-99 refer to the year 1993 and 1999.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

The importance of organic farming varies not only between countries, but also between different commodities within countries. In **France**, for example, pasture is largely under organic systems compared to arable land, while amongst arable crops the share of fruit and vegetables produced organically tends to be higher than for cereals, sugar and oilseed crops. For livestock products growth in organic production has been most rapid for milk and poultry meat. In terms of the share of organic foods in total retail food sales the share varies across countries, but it is also small, for example, around 2% (2003) in the **United States**. Milk, fruit and vegetables account for the major part of organic production and retail sales in both the **United States** and **EU15** (EEA, 2005; OECD, 2003b; USDA, 2005).

Figure 1.9.10. **Share of agricultural land area under certified organic farm management**



StatLink http://dx.doi.org/10.1787/288310605203

1. Data for 1993-95 are unavailable for Australia, Canada, Japan, Mexico, New Zealand, Poland and Portugal.
2. Data for 2002-04 are taken from IFOAM (2007).
3. Value for 1993-95 is 0.01. Data for 1994 are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France.
4. Value for 1993-95 is 0.004. Data for 1993-95 are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3.
5. Value for 1993-95 is 0.001. Data for 1995 are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3.
6. Value for 1993-95 equals data for 1997 (0.14%) and value for 2003 equals data 2001 (0.25%). Data from national source.
7. Value for 1993-95 is 0.02; data are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3.
8. Data for 1993-95 are taken from IFOAM, other data are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3.
9. Australia, Canada, Japan, Mexico, New Zealand, Poland and Portugal are not included in the OECD for 1993-95.
10. Data for the period 1993-95 refer to year 1993, the value is 0%.
11. Portugal is not included in the EU15 for 1993-95.
12. Data for 1994 equal 1993-95 average.
13. Data for the period 1993-95 refer to the year 1993.

Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; OECD Agri-environmental Indicators Questionnaire, unpublished; IFOAM (2007).

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Chapter 2

OECD Progress in Developing Agri-environmental Indicators

2.1. Introduction

This chapter reviews the progress of OECD work on agri-environmental indicators (AEIs), especially in a series of OECD Expert Meetings, held over the period 2001-04 (Box 2.1, *Background and Scope of the Report*, Section II). The indicators described in this chapter are those for which either methodologies and/or data sets are *not* yet at a stage that allows for representative comparative OECD country coverage, as is the case for those in Chapter 1. The OECD Expert Meetings and agri-environmental questionnaires (unpublished) provided the key material for this chapter, as well as for other chapters. Annex 2.A1 provides a list of the indicators covered in this chapter, although a few are not examined here, including the indicators of: greenhouse gases (Section 1.7.3, Chapter 1); and energy (Section 1.4, Chapter 1).

The development of OECD's AEIs has involved intensive collaboration with experts in the relevant areas, co-ordination with other international organisations, and interactive consultation with OECD countries. This chapter examines in:

- ***Section 2.2:*** A review for each indicator area, considering the relevant agri-environmental issue and definitions, followed by an assessment of how far the work has developed in each case, including identifying the main knowledge gaps that need to be addressed for the indicators to be useful for policy monitoring and evaluation; and,
- ***Section 2.3:*** Provides an overall assessment of the common themes that emerge from this review, in terms of examining the indicators against four criteria: policy relevance, analytical soundness, measurability, and ease of interpretation (see also supporting information in Annex 2.A2).

2.2. Progress in developing OECD Agri-environmental Indicators

2.2.1. Soil: Erosion, biodiversity and soil organic carbon

Soil erosion and soil biodiversity

Issues. Soil erosion resulting from agricultural activity occurs not only through the natural agency of wind and water, but also as a result of tillage translocation and mechanical intervention. It occurs across a range of landscapes and affects both agricultural productivity on-site and environmental quality off-site. The interdependence between soil erosion and soil biodiversity is widely acknowledged, thus a range of related indicators reflects the interactions between properties and processes. Damage to soil biodiversity may exacerbate erosion, and the latter accentuate biotic loss. Management practices that degrade soils can negatively impact on soil biodiversity through, for example, reducing the organic matter content, and in turn reduce soil quality. Soil biota are extremely complex and the interrelationships of soil biodiversity indicators with other variables, including soil management, are significant.

Indicators. The OECD Expert Meeting on "*Agricultural Impacts on Soil Erosion and Soil Biodiversity: Developing Indicators for Policy Analysis*" (OECD 2003a) recommended that OECD countries could develop the following indicators, in addition to those covered in Chapter 1.

Soil erosion

i) Area and share of agricultural land affected by tillage erosion in terms of different degrees of erosion, *i.e.* tolerable, low, moderate, high and severe.

ii) Contribution (as a share or physical quantity) of agriculture to off-farm sediment flows into the landscape and water bodies (from water, wind and other erosion sources).

iii) Gross on-farm soil erosion, measured through integrating models of wind, water and tillage erosion.

iv) On-farm and off-farm economic costs of soil erosion.

Soil biodiversity

No specific soil biodiversity indicators were recommended by the Expert Meeting, but experts suggested that countries could exchange information on their soil biodiversity indicator inventory, methodologies, and national case studies revealing the use of these indicators for policy analysis, where available.

Assessment. A lack of scalable, reliable, consistent and comparable datasets is the main limit to developing ***soil erosion*** indicators. In this respect, a comprehensive approach, including consistency in methodologies of modelling, of data collection and use, and collaboration among OECD countries are required in order to develop integrated indicators. While some progress has been made in developing some soil erosion indicators (Section 1.5, Chapter 1), other soil erosion indicators, see above, are less advanced. But in **Canada**, for example, risk indicators of tillage erosion on cropland have been fully developed at the regional as well as national level in addition to indicators of water and wind erosion (Lefebvre *et al.*, 2005).

Further research is needed, for example, to develop measurements of off-site deposits of eroded soil. Developing complete data systems would facilitate this process covering varying types of erosion – water, wind and tillage – as would systematic long-term monitoring (augmented by the establishment of international monitoring protocols) of all relevant variables including land use.

Soil biodiversity embraces genetic, taxonomic and functional forms which interact to provide a wide range of ecological services. Individual agricultural practices may affect this balance, therefore destabilising the ecosystem. It is generally believed that ploughing reduces diversity whilst liming tends to increase species richness in nutrient-poor and semi-natural grasslands. The over-use of agrochemicals and organic waste can also have a detrimental impact on soil organisms (OECD, 2001).

Measurement of soil biodiversity is complex (Box 2.1). Conceptual approaches can vary from taxonomic, functional, ecological, to trophic structure. Soil organisms are multifunctional, highly diverse and difficult to systematise both spatially and temporally. The heterogeneity of soil environments is a reflection of biotic activity which in turn affects biotic diversity and function. The diversity in approaches to monitoring biodiversity (at species, entity, or soil activity levels) adds to the complexity in deriving appropriate indicators.

Measuring soil biodiversity requires identification of scale (local, regional, national); the method of measurements; and the minimum set of elements needed to facilitate comparison, yet also need to reflect heterogeneity. The task is made more demanding since scientific research has varied from impact studies, population characterisation, functional analysis and methodological testing.

Box 2.1. **Soil biodiversity in agricultural land**

Soil biodiversity contributes to crop productivity, soil functions and agro-ecosystems on which the agricultural sector depends. The proper functioning of soil is essential to support life. Yet little is known about the biodiversity of soils, nor how agricultural activities can affect a soil's biological properties. Thus, a greater knowledge of the impacts of farm management practices on soil biodiversity is needed.

Several OECD countries have developed or are progressing with strategies on conserving soil biodiversity stemming from the UN Convention on Biological Diversity. The **Canadian** Biodiversity Strategy, for example, was developed in 1995 to enhance national conservation efforts on the sustainable use of biological resources. **Canada** aims to increase awareness and understanding about soil biodiversity in agriculture as research shows that the soil biotic system and its biodiversity can have wider effects with the capacity to help clean air and water (Fox *et al.*, 2003).

In the **Netherlands** there is concern over the sustainable use of ecosystems, due to agricultural use of soils. A biological indicator has been developed to assess the condition of soil quality (Anton *et al.*, 2003).

The **United Kingdom** recognises that agricultural land use and management practices may have significant (positive and negative) impacts on different components of soil biodiversity. Farmers are encouraged to consider nature conservation and environmental protection practices, as well as biomass production and heritage interests in order to maintain soil functions (Black *et al.*, 2003).

Given the complex nature of the relationships between soil biodiversity, farming practices and agricultural systems on the one hand, and groups of organisms and soil process on the other, appropriate assessment methods are necessary in this process. In this respect, a minimum set of soil biodiversity indicators, which can be adapted as further information is acquired, might include data on micro-organisms; meso- and macro-fauna; and total organic carbon.

Soil organic carbon

Issues. In response to the debates over global climate change, since 1992 the United Nations Framework Convention on Climate Change (UNFCCC) has been concerned with carbon emissions and current trends affecting the atmosphere. Emissions targets and trading in sequestered carbon or sinks are laid out in the *Kyoto Protocol* (1997). In the case of soil organic carbon, the lack of regular and consistent data on carbon stocks in agricultural soils makes it difficult to calculate accurate trends in changes in the organic carbon levels in soils.

In this context, there has been extensive research on soil organic carbon (SOC) given that longer term sequestration of SOC has the potential to mitigate greenhouse gas emissions (Rose, 2003), although the research on these relationships is still in its infancy in many OECD countries. However, this situation is expected to be improved, as the UNFCCC inventories will in future categorise carbon sequestration in agricultural soils separately from soil emissions in general (Section 1.7.3, Chapter 1). The proliferation of national carbon accounting systems is a pre-requisite for such developments, as is a framework for utilising the output of existing models and databases.

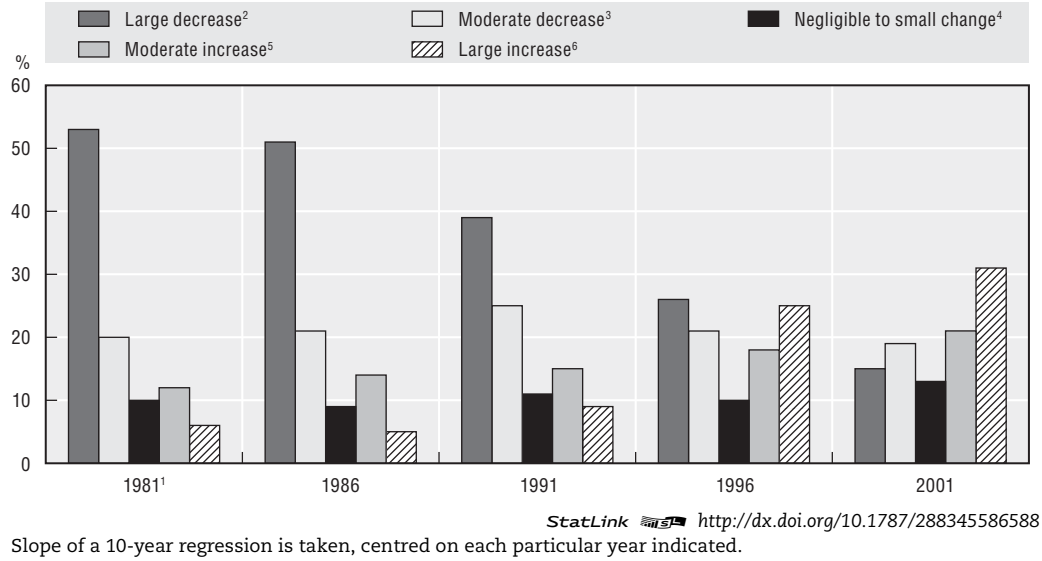
Indicators. The OECD Expert Meeting on "*Soil Organic Carbon and Agriculture: Developing Indicators for Policy Analysis*" (OECD, 2003b), recommended that OECD countries could develop the following indicator:

- Change in total soil organic carbon (SOC) in agricultural land over time.

Assessment. The high estimated opportunity cost of soil carbon in agricultural activities is a reflection of the role of soil organic matter in providing a vehicle for nutrient and water storage and release, as well as the filtration of air and water. Farm practices provide the key drivers of changes in SOC levels. The data required to explain the interactions between these variables cover not only soils, but also climate (*e.g.* degree of wind and precipitation); land use and cover; and farm management techniques. At the same time the SOC indicator needs to be considered alongside other indicators of soil and water quality, to better understand the relationships between these indicators and thus the interactions between the variables covered by them.

A few OECD countries have already begun to monitor changes in SOC and reported them to the UNFCCC. In **Canada**, the level of SOC in farmland soils increased during 1981-2001 (Figure 2.1, Lefebvre *et al.*, 2005, Liang *et al.*, 2003; Patterson *et al.*, 2003). There has been a marked increase in the share of farmland within the largely and moderately increasing class of SOC (Figure 2.1). These positive changes can be mainly attributed to improvement of crop management practices, including reduction in tillage intensity, a reduction in summer fallow on the Prairies and an increase in hay and forage crop production (Lefebvre *et al.*, 2005). Nevertheless, data for 2001 shows that Canada still has a significant share of farmland (34%) within the moderate to large decreasing class of SOC, partly due to excessive erosion on cropland with annual crops in Eastern Canada (Figure 2.1, Lefebvre *et al.*, 2005).

Figure 2.1. **Canadian soil organic carbon stocks in agricultural soils by different classes**



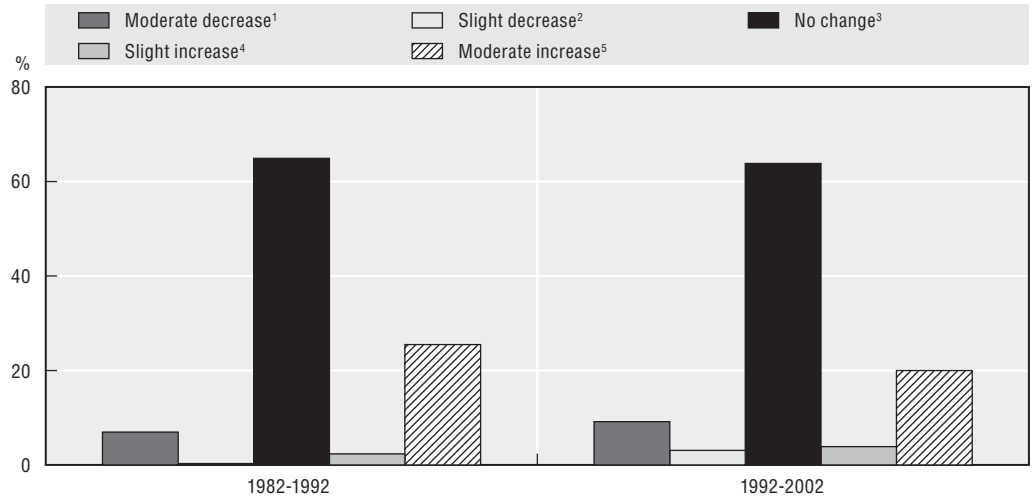
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1. Slope of a 10-year regression is taken, centred on each particular year indicated.
2. Large decrease is defined as more than 50 kg decrease in soil carbon per hectare per year.
3. Moderate decrease is defined as between 10 and 50 kg decrease in soil carbon per hectare per year.
4. Negligible to small change is defined as between –10 to 10 kg change in soil carbon per hectare per year.
5. Moderate increase is defined as between 10 and 50 kg increase in soil carbon per hectare per year.
6. Large increase is defined as more than a 50 kg increase in soil carbon per hectare per year.

Source: Lefebvre *et al.*, 2005.

Agricultural soils in the **United States** sequester around 4 million tons of carbon annually, accounting for about 2% of total terrestrial carbon. SOC stocks in agricultural soils declined between 1982 to 1992 but overall changed little over the period 1992 to 2002 (Figure 2.2; USDA, 2004). While adoption of conservation tillage practices have helped toward increasing SOC, more extensive implementation of conservation management practices could lead to sequestration at much higher rates (Ogle *et al*., 2003).

Figure 2.2. **United States soil organic carbon stocks in agricultural soils by different classes**



StatLink http://dx.doi.org/10.1787/288370210271

1. Moderate decrease is defined as more than 50 kg decrease in soil carbon per hectare per year.
2. Slight decrease is defined as between 10 and 50 kg decrease in soil carbon per hectare per year.
3. No change is defined as between –10 and +10 kg change in soil carbon per hectare per year.
4. Slight increase is defined as between 10 and 50 kg increase in soil organic carbon per hectare per year.
5. Moderate increase is defined as more than 50 kg increase in soil organic carbon per hectare per year.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

Analytical and sampling protocols are required to ensure consistency and comparability, particularly with respect to soil profile depth. A major concern involves measuring potentially very small changes in SOC that might occur within a short time period. Model choice should be determined by biophysical heterogeneity and data availability. The dynamics of carbon and nitrogen cycling are closely linked and other indicators, such as some soil biodiversity indicators, can be extracted from the data sets that produce the SOC indicator.

2.2.2. Water: Use and water quality

Issues. Agriculture is a significant user of water and the main contributor to water pollution in rural areas of many OECD countries. While the links between the use and quality of water are pronounced in some cases, agriculture can, at the same time, provide eco-systems services such as groundwater recharge and flood control. In this context, indicators with respect to water use and quality are crucial to reflect the current status and trends in these variables, as well as links to agricultural water management indicators.

Indicators. The OECD Expert Meeting on "*Agricultural Impacts on Water Use and Water Quality: Developing Indicators for Policy Analysis*" (OECD 2004a) recommended that OECD countries could develop the following indicators, in addition to those covered in Chapter 1:

Water use

1. A net agricultural groundwater balance to take into account both agricultural withdrawals and recharge of groundwater.
2. Annual share of rivers/lakes where agricultural water extraction results in rivers/lakes falling below (seasonal) a minimum reference level.
3. Impact of agricultural water use on ecosystem health (*e.g.* wild species and wetlands).
4. Trend in the average value of irrigated agricultural product(s) per unit of irrigation water consumed (or alternatively water withdrawn or licensed water allocation, where the water withdrawn could be the *gross* value of total water withdrawn or the *net* value of total water withdrawn minus the value of water returned to rivers and lakes and recharged to groundwater).
5. Charges for water supplies to farmers relative to water supply charges for other major users (industry and urban).

Water quality

1. Salt concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas.
2. Pathogen (faecal indicator or pathogenic bacteria) concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas.
3. Share of pathogen contamination derived from agriculture in surface waters and groundwater.

Assessment. With respect to groundwater use, measuring the net balance (as opposed to outward flows) would provide a more comprehensive indicator, with the information augmented by data on the quality of outward and return flows (Section 1.6.1, Chapter 1). In this regard, recharge of groundwater as well as return flows to rivers has been measured in countries, such as in **Japan** and **Korea** (Table 2.1).

Table 2.1. **Net water balance in a Japanese rice field irrigation system: 2003**

	10 000 m^3/1 000 ha/120 days
Input (into rice field)	**2 220**
Intake from river	1 920
Rainfall	900
Withdrawal evapotranspiration	600
Output (from rice field)	**2 220**
Return flow to a river	1 370
Groundwater recharge[1]	450
Other	400
Ratio of return flow to river/intake from river (%)	71
Ratio of groundwater recharge/intake from river (%)	23

StatLink http://dx.doi.org/10.1787/301817702474

1. A part of water is discharged into downstream rivers after groundwater recharge.

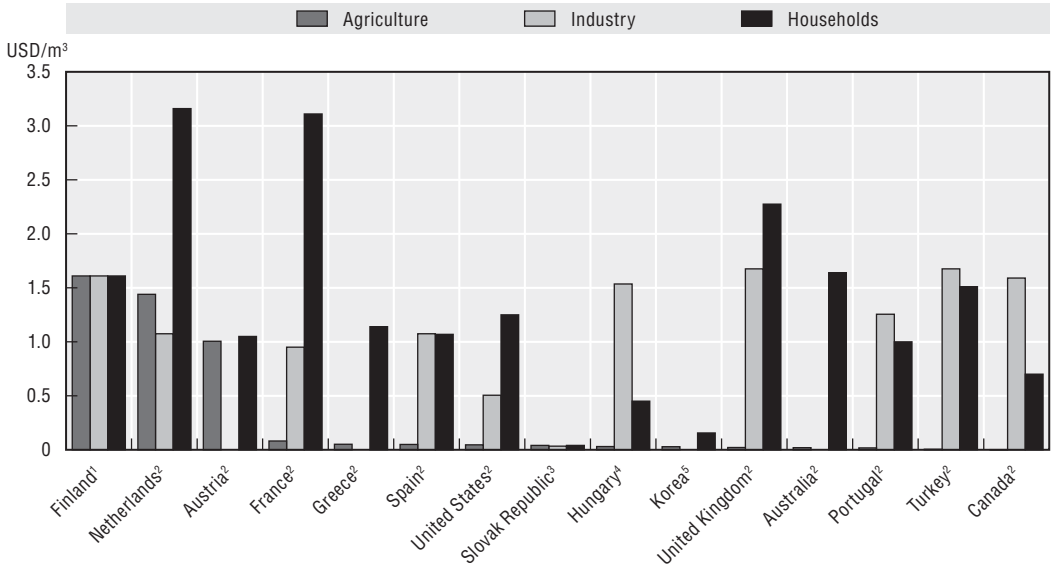
Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

Indicators of volumes used in, and area under, irrigation could describe one aspect of water use efficiency, with a related indicator describing economic efficiency or agricultural output per unit of water consumed. In the **United States**, for example, the average value of irrigated agricultural products per unit of irrigation water is more than four times higher than that of non-irrigated products. Water use indicators may also need to reflect humid as opposed to arid and semi arid conditions.

The indicator of charges for water supplies to farmers relative to water supply charges for other major users (industry and urban) reveals that in many OECD countries agricultural producers pay substantially less for water deliveries than industrial and urban users (Figure 2.3). To an extent the difference in water charges between agriculture and others users reflects the widespread support provided to OECD irrigated farming (Chapter 1). Some caution is required, however, in comparing agricultural water charges with other user charges because water supplied to agriculture is usually of a lower quality than that provided to households and, on occasion, industry; while the capital costs of water conveyance systems are generally lower for agriculture than for household or industry. In addition, variations in water charges between users may not reflect differences in water use efficiency, for example, public water supplies in a particular water catchment

Figure 2.3. **Agricultural, industrial, and household water charges**

Late 1990s-early 2000s



StatLink http://dx.doi.org/10.1787/288410413523

Note: Some caution is required in comparing agricultural water charges with other user charges because water supplied to agriculture is usually of a lower quality than that provided to households and, on occasion, industry; while the capital costs of water conveyance systems are generally lower for agriculture than for households or industry.

1. Data from OECD Agri-environmental Indicators Questionnaire, unpublished.
2. For agriculture, industry, and households, charges are the median values for the range of charges for each category, and data for late 1990s, see OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France. Agricultural water charges are less than 0.1 USD/m^3.
3. The charges for water used by agriculture and households are the same (0.04 USD/m^3) but for industry are lower (0.034 USD/m^3), data for 2002.
4. Agricultural water charges are less than 0.1 USD/m^3, data for 2003.
5. For households and industry, water charges are for the year 2000, and for agriculture (paddy field), for the year 1995. Agricultural water charges are less than 0.1 USD/m^3.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

might be drawn from groundwater while that for agriculture from a river. Moreover, water charges may not reflect the value of positive externalities that can be generated by agriculture, such as groundwater recharge, as discussed above.

The development of water quality indicators is complicated because different reference levels are used to define national quality standards, ranging from drinking water to other water uses, including for environmental and recreational use. Similar issues arise with respect to salt and pathogen content, where there are no common standards or indicators across countries (Box 2.2).

Refinement of current measurement techniques of water use and quality is necessary, but the main need of future research is to broaden the range of indicators and associated data, to include measurements of the environmental and social consequences for water

Box 2.2. **Agricultural livestock pathogens and water pollution**

Pathogens in livestock manure (*e.g.* bacterial, parasites and medicines), especially from dairy cattle and pigs, can be transmitted in waterways directly from faecal discharges, leaking slurry/manure stores and from field application of manure. These pathogens can damage fish and shellfish in aquatic ecosystems, and cause human health problems through impairing drinking water quality. There is little information available about how the release of these pathogens into water bodies may affect human health or eco-systems. However, a study in the **United States** found that 9% of farm streams registered positive for several pathogens due to the frequency of manure spreading (OECD 2004b).

Many OECD countries have established guidelines or standards for pathogens in water bodies, in particular drinking water. For example, national guidelines exist for *E. Coli*, which must be undetectable in at least 100 ml of drinking water, in **Canada, Japan, Korea, New Zealand** and the **European Union.** Whilst methods of establishing standards may differ between OECD countries, they all share the objective of reducing water contamination to protect aquatic life and ensuring the safety for human consumption of water.

About 1 000 **Canadians** suffer from *E. Coli* annually, with the majority of recent cases relating to consumption of infected meat or cheese. In May 2000, seven people died and more than 2 000 became ill when the water system of an Ontario town was contaminated with *E. coli*. It is believed that the contamination came from cow manure that had leached into the water table. *Canada* also operates guidelines for freshwater and marine waters and has identified "at risk" areas where higher pathogenic bacterial contamination of surface or groundwater is likely. This especially occurs next to intensive livestock production.

In **Germany** studies show that the harmful effects of pathogens from livestock are reduced in the soil and groundwater aquifers within 50 days of their release in such a way they do not impair drinking water quality. For this reason, slurry and manure application is forbidden in specified water abstraction zones taking into account groundwater leaching velocity and the 50-day release threshold. For example, if the groundwater velocity amounts to 1 metre per day no livestock waste application is allowed around the pumping within a distance of 50 metres).

In the **United Kingdom** investment in the sewerage industry's infrastructure has significantly improved the quality of surface water bodies and highlighted areas where diffuse pollution from agriculture is compromising "guideline" standards, in particular North-West England and Western Scotland. Research is currently being conducted to identify the proportion of contamination derived from agriculture.

use and quality resulting from agricultural activity. There is currently a lack of information regarding these environmental and social interactions, as well as on agriculture's provision of ecosystem services, and the impact of agricultural water use on aquatic ecosystems (Box 2.3). Additionally, better understanding of the links between water use and quality could facilitate the development of both sets of indicators as, particularly with respect to irrigation water, these links can be significant.

Box 2.3. **The impact of agriculture on aquatic ecosystems**

Changes in river flow patterns contribute to the disturbance or degradation of aquatic ecosystems. There is an intricate balance between water levels in rivers, wetlands, groundwater sinks, etc., which can be disrupted by the disproportionate use of one of these resources. For example, withdrawal of excessive amounts of groundwater (in excess of the rate of recharge) can cause the reduction of river flows, the complete stoppage of flows or in severe cases the drying up of streams or the reversal of river flows.

Defining minimum flows for rivers is important to safeguard the water levels in rivers and streams. Monitoring water levels and the quality of rivers will indicate the extent of human interference and the effects of natural events (*e.g.* flooding or drought). Where river flows are regulated, it is expected that aquatic ecosystems can be relatively undisturbed.

Data are limited on the effect that over-extraction of water either from rivers or groundwater for agricultural purposes has on river flows or aquatic ecosystems. In some OECD countries in **Australia, Europe** and **North America** they have experienced problems in retaining minimum river flows as a result of overexploitation by irrigated agriculture. Therefore, monitoring minimum water flow rates in rivers is becoming a key part of environmental planning in river basins.

Source: OECD (2001).

Although current approaches to measuring these indicators have yielded valuable information, other frameworks and methodologies may improve understanding of agriculture's impact on water use and quality, particularly with respect to differentiating impacts by source. In this respect, the impact of alternative farm and water management practices may lead to helpful insights and the use of frameworks that encompass spatial scales that vary from the local to the international level.

2.2.3. Biodiversity: Genetic, wild species and ecosystem diversity

Issues. OECD has developed an Agri-biodiversity Framework to help organise and identify suitable agri-biodiversity indicators (Section 1.8, Chapter 1). In addition, the biodiversity indicators in Chapter 1 take account of the *Convention on Biological Diversity* identification of three levels of biodiversity: the genetic, species and ecosystem levels.

Indicators. The OECD Expert Meeting on "*Agriculture and Biodiversity: Developing Indicators for Policy Analysis*" (OECD, 2003c) recommended that OECD countries could develop the following indicators, in addition to those covered in Chapter 1:

Genetic resource diversity

- Number and share of national native crop varieties (*i.e.* cereals, oil crops, root crops, fruit and vegetables) that are considered to be at risk of extinction (*i.e.* critical or endangered risk status).

Wild species diversity

- Number of ecologically indicative wild species using agricultural land.

Ecosystem diversity

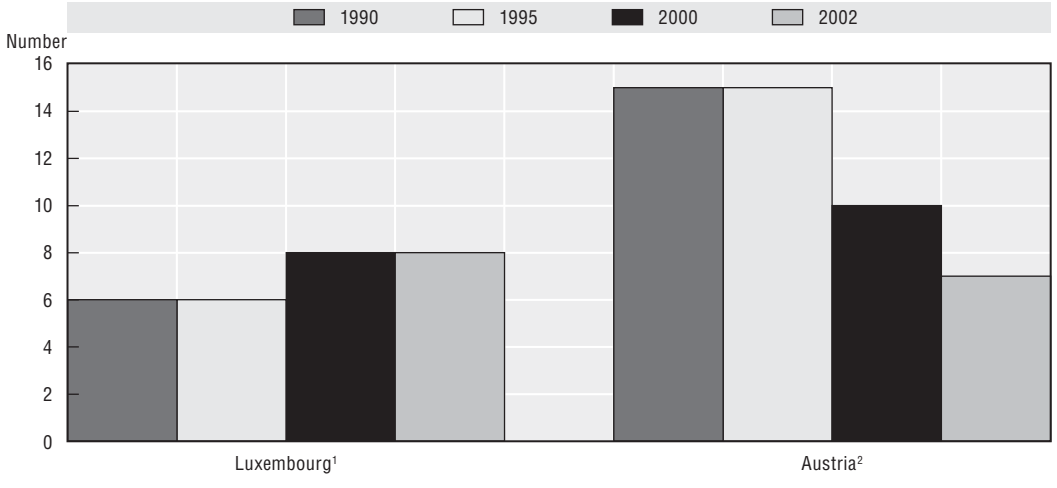
- Quality and quantity of habitat features (*e.g.* patch size, linear features and networks) and their spatial composition (*e.g.* fragmentation, vertical structures, mosaics) across agricultural land.

Linkages between habitats and species

1. *Habitat-Species Matrix*, linking changes in the area and management of all agricultural habitat types on wild species (flora and fauna) through data from either explicit field observation or indirect information (*e.g.* expert knowledge).
2. *Natural Capital Index*, the product of the quantity of agricultural habitat types and their quality in terms of wild species abundance, richness, habitat structure and management, measured between the current state of the agro-ecosystem and a baseline state.

Assessment. For indicators related to the ***diversity of genetic crop resources***, only a few countries have developed a database on the national crop varieties that are extinct, critical or endangered from being lost, or not at risk (Figures 2.4 and 2.5). The **United States** also reports genetic erosion is less of a problem for wheat and maize, although genetic uniformity of rice, beans and minor crops is a concern (Chapter 1). Identifying crop varieties that are endangered can be difficult. For example, a plant variety may be endangered *in situ*, but the genetic material of the variety could be held *ex situ* in a gene bank.

Figure 2.4. **National crop varieties that are endangered**

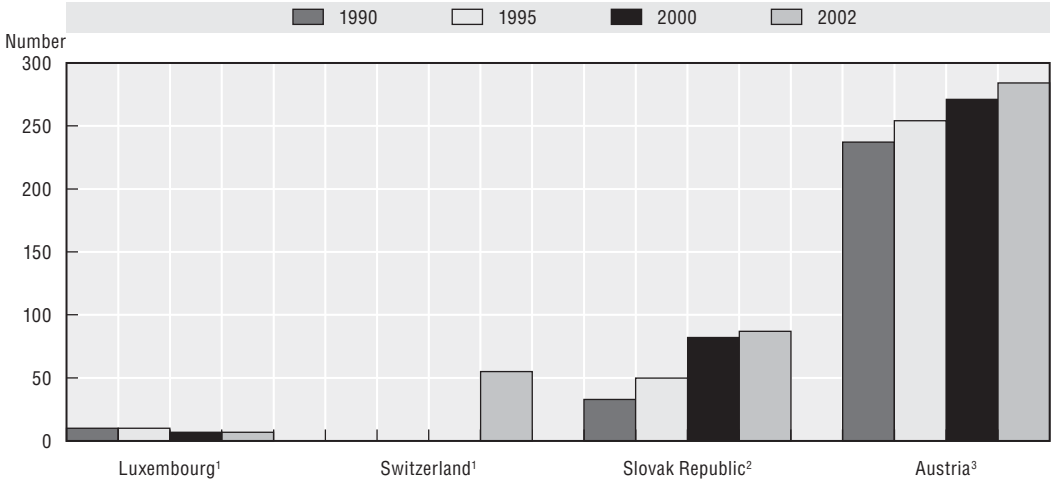


StatLink http://dx.doi.org/10.1787/288448855374

1. Crop varieties include fruit and vegetables.
2. Crop varieties include: cereals, oil crops and fruit.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

Figure 2.5. **National crop varieties that are not at risk**



StatLink http://dx.doi.org/10.1787/288456310701

1. Crop varieties include only fruit.
2. Crop varieties include: cereals, oil crops, root crops and vegetables.
3. Crop varieties include: cereals, oil crops and fruit.

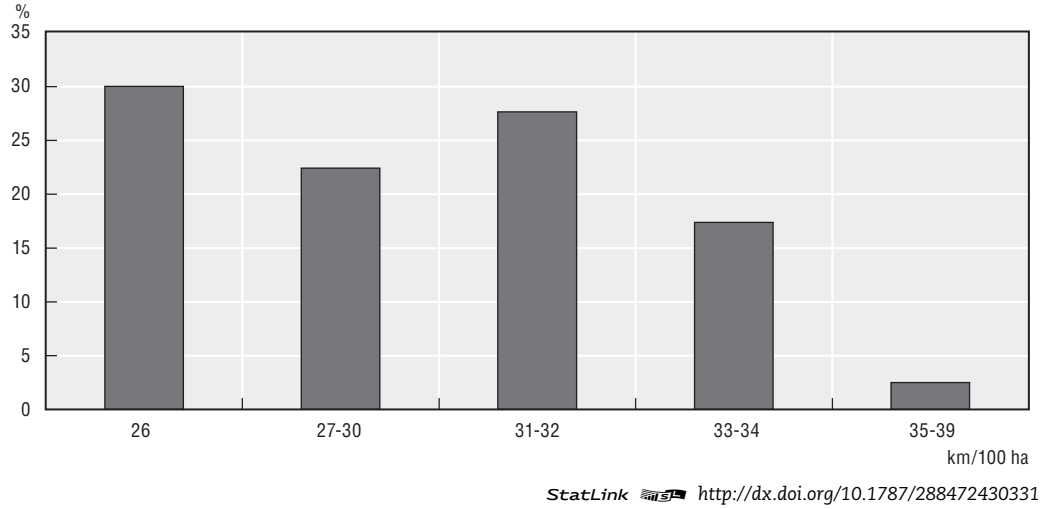
Source: OECD Agri-environmental indicators Questionnaire, unpublished.

Some progress has been made across OECD countries in developing indicators of ***wild species***, especially bird populations (Section 1.8.2, Chapter 1). But data and indicators related to other wild flora and fauna species are poorly developed.

Some progress is being made on the analysis of ***ecosystem diversity***, especially in terms of improved monitoring of agricultural semi-natural habitats (*e.g.* improving the distinction between different types of grasslands). In addition, some countries are developing methods and measurements of the quality of agricultural habitats, notably the structure of habitats. For example, **Finland** has developed an indicator of the edge density of field margins (Figure 2.6; Hietala-Koivu, 2003), which shows the abundance (or lack) of the ditch

Figure 2.6. **Edge density of agricultural fields in Finland**

2002



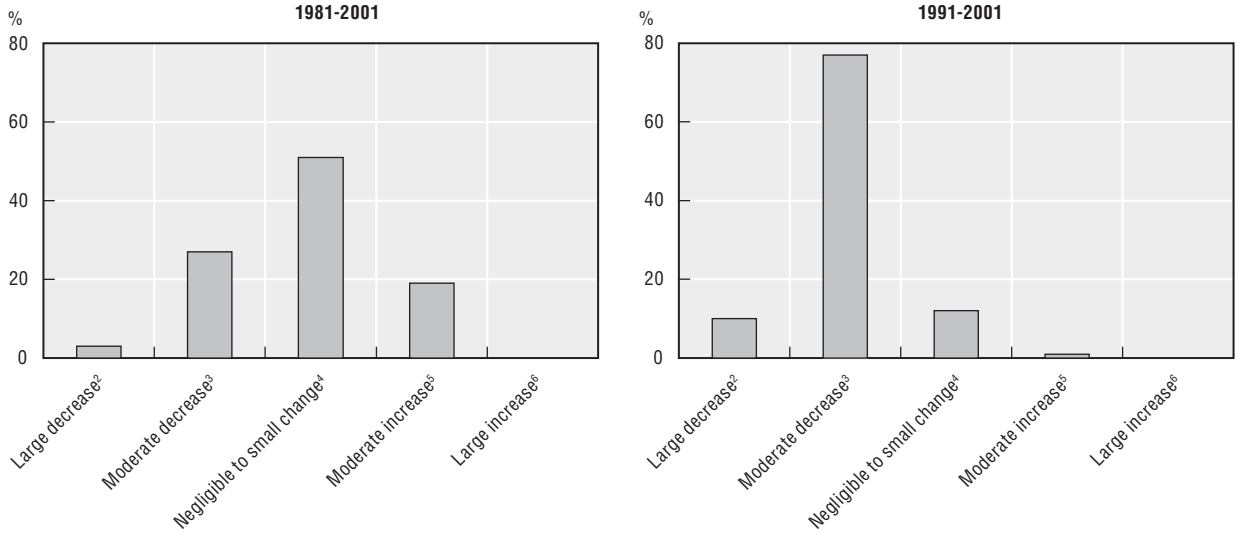
StatLink http://dx.doi.org/10.1787/288472430331

Source: Hietala-Koivu (2003).

boundaries between fields and other forms of land use (*e.g.* forest, roads). The indicator also shows the regional variation in edge density, and that where edge density is low this is likely to adversely impact biodiversity and cultural landscape values.

Habitat-Species Matrix and *Natural Capital Index* indicators integrate habitat quantity and quality indicators to provide information on how land use and land cover changes are affecting wild species (flora and fauna) in their use and requirements of habitats in agro-ecosystems (OECD, 2003c). The *Habitat-Species Matrix* (termed as a habitat capacity index in Canada) has been developed in some countries, such as **Canada** that aims to improve understanding of how wildlife habitats on agricultural land could be affected by sectoral, market and policy changes (Lefebvre *et al.*, 2005). In Canada, while a moderate improvement (increase) in habitat capacity was observed on nearly 20% of farmland between 1981-2001, there was a corresponding reduction in habitat capacity (moderate and large decrease) on nearly 30% of farmland (Figure 2.7). This was mainly occurred during 1991 to 2001 due to an expansion in cropland and decline in species-rich natural pasture (Lefebvre *et al.*, 2005).

Figure 2.7. **Share of Canadian farmland in various classes of the habitat capacity index**[1]



StatLink http://dx.doi.org/10.1787/288513561267

1. The habitat capacity index is calculated by relating the number of species that use each of the five selected land cover categories (*i.e.* cropland, summerfallow, tame pasture, natural pasture and "all other land") to the relative area occupied by each land cover type.
2. Large decrease is defined as more than a 10% decrease during the period in each figure.
3. Moderate decrease is defined as between a 2.5% and 10% decrease.
4. Negligible to small change is defined as between a –2.49 and 2.49% change.
5. Moderate increase is defined as between a 2.5% and 10% increase.
6. Large increase is defined as more than a 10% increase.

Source: Lefebvre *et al.*, 2005.

The *Natural Capital Index* (NCI) is being developed in the context of the implementation of the Convention on Biological Diversity (OECD, 2001). The NCI is calculated as the product of the quantity of the ecosystem (*e.g.* agro-ecosystem) multiplied by the quality of the ecosystem (*i.e.* average of changes in wild species numbers from a baseline period), and has similarities with the habitat-species matrix. The **Netherlands** has been active in developing the NCI, both at the broad national ecosystem level and for agro-ecosystems, tracking the decline in natural capital associated with agro-ecosystems in the country (Brink, 2003; RIVM, 2004).

2.2.4. Land: Landscapes and ecosystem functions

Agricultural landscapes

Issues. Agricultural landscape indicators attempt to show the relationship between agricultural structures and practices, and landscape structures, functions and values. These relationships are complex, often highly site specific and open to differing interpretations, reflecting the diverse situations among countries.

Indicators. The OECD Expert Meeting on "*Agriculture Impacts on Landscapes: Developing Indicators for Policy Analysis*" (OECD 2003d) recommended that OECD countries could develop the following indicators:

1. Landscape Structure: land use, cover, patterns and cultural features (*e.g.* hedges and historic farm buildings), some of which are partly covered in other indicator areas.
2. Landscape Functions: recreation (*e.g.* accessibility), cultural identity, tranquillity, and ecosystem functions covered in the biodiversity indicator area.
3. Landscape Values: monetary value of agricultural landscapes calculated through the use of methods, such as contingent valuation.

Assessment. Agricultural landscape indicators should ideally cover three areas: structures; functions; and societal value. Where local/regional landscape targets (*e.g.* cultural elements) have been defined, the national level indicator could be expressed in terms of the percentage of regions or sub-regions that meet their own targets. Management practices which also affect landscape are also considered in the context of the farm management group of indicators (Section 2.2.5).

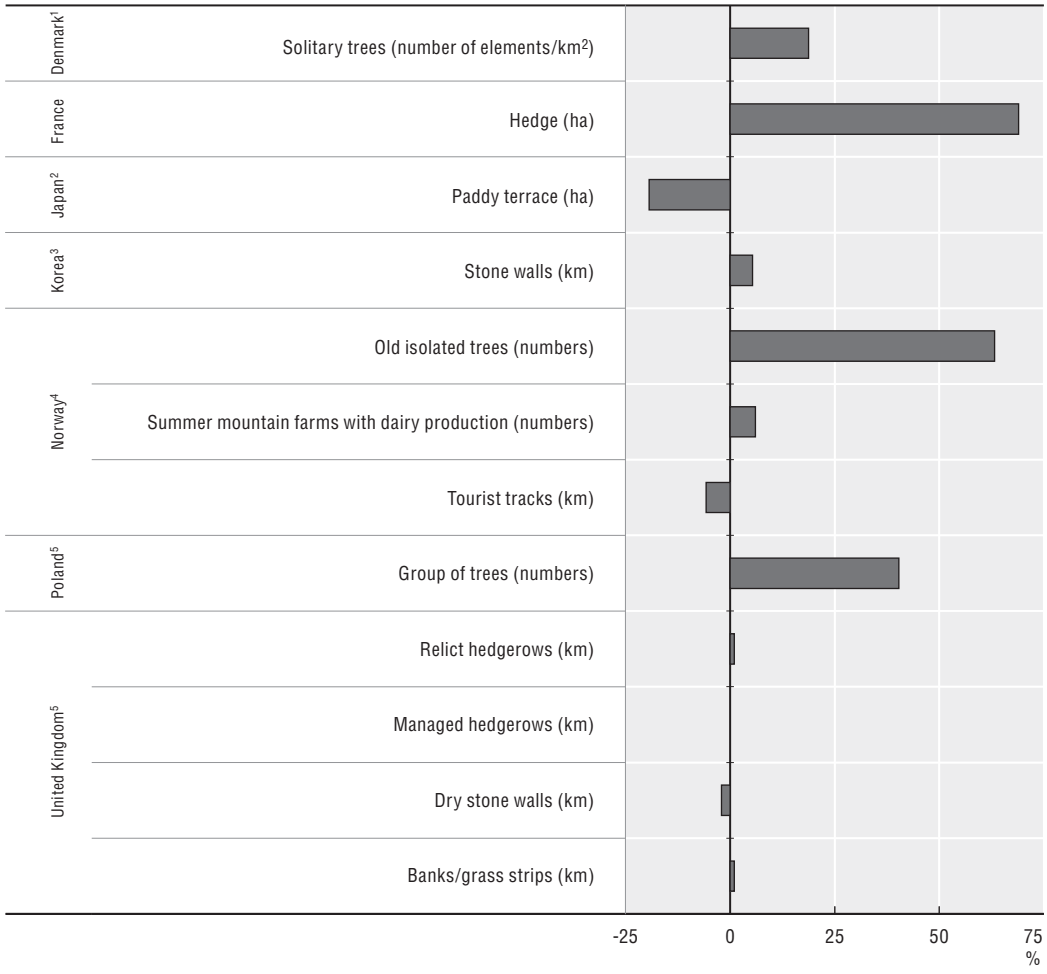
With regard to indicators of agricultural function and values, no consistent data across OECD countries are available, as a range of different methods has been adopted or are under development, while marked differences in data gathering activities (*e.g.* surveying or sampling landscape, collection of statistical data) also exist between OECD countries. In this context, the current emphasis has focused on landscape structure such as land use, cover, patterns and cultural features, such as stone walls, historic buildings, etc., in terms of recording the current status and change rather than anticipating future trends.

Regarding landscape structures, much less information is available concerning land cover, patterns and cultural features across OECD countries compared to land use. Nevertheless, in the case of cultural features, several countries have measured these changes over the past decade (Figure 2.8). The changes in these elements have been usually measured at the regional level, in particular, in **Europe**. For example, the European Environment Agency has established comparable agricultural landscape indicators, such as measuring field patch density and linear features (EEA, 2005).

For a more comprehensive approach, an Agri-Landscape Indicators Framework which was developed through the OECD Expert Meeting on Landscape, could be used by countries (OECD, 2003d). This links the range of indicators expressed through regional and local targets to policy objectives. But more research is needed to understand the linkages between policy and landscape development. Few countries have clearly defined targets for landscape conservation, or have undertaken trend analyses of landscape feature developments. In this respect, future emphasis on spatial differences is appropriate.

Figure 2.8. **Cultural landscape features on agricultural land**

% change 1990 to 2000



StatLink http://dx.doi.org/10.1787/288557083627

1. Data for 1990 and 2000 refer to 1991 and 1996, respectively.
2. Data for 2000 refer to average of 2001-03.
3. Only in Cheju Provincial Area.
4. Data for 2000 in tourist tracks refer to 1995.
5. Data for 2000 refer to 1998.

Source: OECD (2001); OECD Agri-environmental Indicators Questionnaire, unpublished.

The current emphasis on structural indicators could be broadened to capture more fully the functional diversity of landscapes (recreation, cultural identity, tranquillity); farm management variables (farming systems, landscape provision); and societal demand. A better understanding of the relationships between these and other indicators, together with refinement of the methodologies of data collection and greater uniformity of techniques used by different countries in data collection, would be necessary to use these indicators in policy analysis.

Land ecosystem functions

Issues. There are a range of ecosystem functions or services associated with agriculture, and land ecosystem function indicators are designed to reflect changes in the provision of some of these services. An illustrative example of ecosystem services linked to agriculture

concerns the potential of farming to help control the incidence and severity of floods and landslides. Increasing climate variability is leading to the growing incidence and severity of flooding and landslides in many regions across the world. Agriculture can be both the cause and solution to help mitigate damage from floods and landslides depending on various factors including which farming practices and systems are adopted.

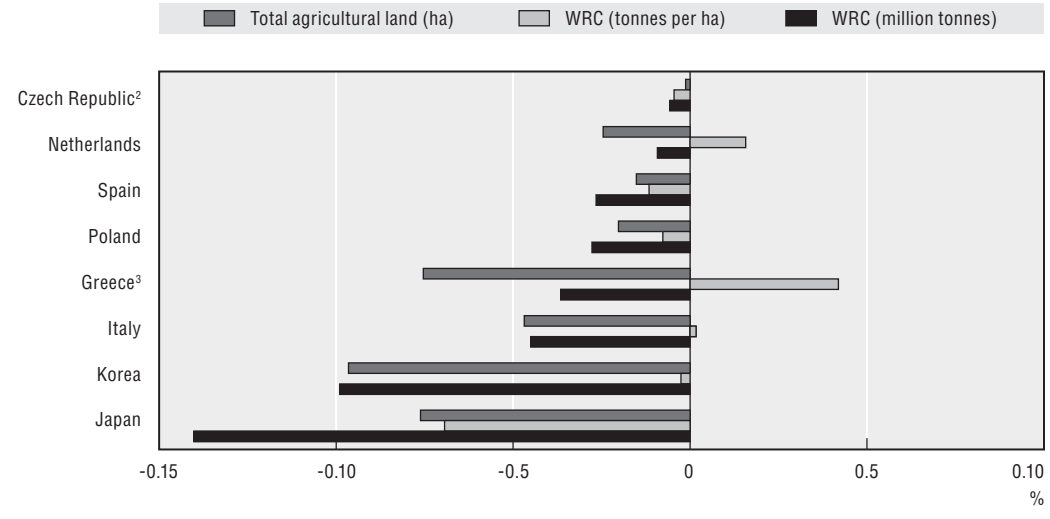
Indicators. The OECD Expert Meeting on "*Agriculture and Land Conservation: Developing Indicators for Policy Analysis*" (OECD, 2004c) recommended that OECD countries could develop the following indicators:

1. Water retaining capacity (WRC): quantity of water that can be retained in the short term, in agricultural soil, as well as on agricultural land where applicable (*e.g.* flood storage basins) and by agricultural irrigation or drainage facilities.
2. Water retaining capacity by agricultural irrigation or drainage facility (Wf): extent to which on-farm water storage facilities retain water (*e.g.* on farm dams, dykes, canals, etc.).
3. Landslide mitigation index (LMI): proportion of managed agricultural land within the agricultural land area subject to landslide risk.

Assessment. The WRC indicator describes the quantity of water that can be retained in the short term by agricultural soils; on agricultural land such as flood storage basins; and by on-farm water storage such as irrigation and drainage facilities. The lack of available national coefficients of WRC per area is the main constraint in developing this indicator. Nevertheless, the WRC has been calculated for several countries and shows that the WRC has declined in all countries over the past decade (Figure 2.9). Also the indicator of water retaining capacity of farm irrigation or drainage facilities (Wf), varied among countries

Figure 2.9. **Water retaining capacity of agriculture**[1]

% change 1990-92 to 2000-02

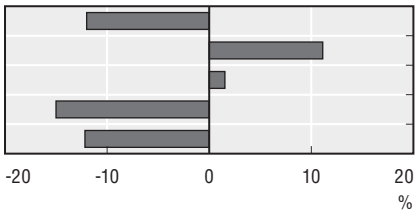


StatLink http://dx.doi.org/10.1787/288607865006

1. The WRC of agricultural facilities is not included.
2. Data for 1990-92 refer to 1993.
3. OECD estimates for WRC coefficients based on OECD (2001).

Source: FAO Database; OECD (2001); OECD Agri-environmental Indicators Questionnaire, unpublished.

Figure 2.10. **Water retaining capacity for agricultural facilities**



	% change 1990 to 2002	1990	2002
		Million tonnes	
Korea	–12	3 758	3 295
Switzerland	11	0.9	1
Slovak Republic[1]	2	65	66
Japan	–15	5 897	4 987
Italy[2]	–12	5 155	4 527

StatLink http://dx.doi.org/10.1787/288657022861

1. Data include small dams only.
2. Data for 2002 refer to 2000.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

(Figure 2.10). In countries where both the WRC and Wf indicators have declined significantly, such as **Italy** and **Japan**, it is implied that the potential risk of flooding has increased during the past decade.

The WRC indicator could be further improved by taking into account different soil conditions and farm management practices, while the Wf indicator could also be further developed to reflect the ability of agriculture to retain water during periods of drought. An approach that includes the water retaining capacity of non-agricultural land use, within the catchments, would provide a more holistic view of the potential of different land use types (*e.g.* agriculture, forest) to help mitigate floods and landslides. A few countries have also begun work on developing the landslide mitigation indicator (**Hungary** and **Japan).** More generally land ecosystem function indicators could be better integrated into policy analysis and contribute to international initiatives, such as the projects of the International Flood Network launched during the Third World Water Forum in 2003.

2.2.5. Farm management

Issues. The focus of farm management has changed over time to include productivity within the broader concept of sustainability. Farming systems are constantly evolving and their environmental impact is always complex, reflecting the interaction of the key agents in this process: farmers, policy makers, and markets. A more holistic and environmental focus on farm management indicators needs further development, in addition to those covered in Section 1.9, Chapter 1.

Indicators. The OECD Expert Meeting on "*Farm Management Indicators and the Environment*" (OECD, 2004d) recommended that OECD countries could develop the following indicators, in addition to those included in Chapter 1:

Environmental farm management plans

- Number (area) and share of farms (agricultural land area) under environmental farm management plans.

Nutrient management

- Number and share of farms (agricultural land area) using nutrient balances.

Pest management

- Number and share (agricultural land area) of farms with appropriate storage/handling/cleaning and disposal facilities for treatment of pesticide wastes (*i.e.* packaging and unused pesticides).

Soil management

- Number and share of farms where soil biophysical properties are monitored as part of the soil test programme and/or used as land management decision support tool.

Water management

1. Area and share of agricultural land that is drained.
2. Area and share of drained land under different forms of drainage technology (*e.g.* surface, subsurface, controlled).

Landscape management

- Number (area) and share of farms (agricultural land area) under public and private schemes committed to natural and cultural landscape maintenance and enhancement.

Farm management capacity

1. Number and share of farmers participating in agri-environmental education programmes.
2. Expenditures on agri-environmental management research and extension as a share of total agricultural budgetary expenditures on research and extension.

Assessment. The range of farm management indicators (FMIs) need to reflect the complexity and diversity of agricultural systems, with reliable data derived from spatially and temporally appropriate levels. The obstacle in developing FMIs is that much national census and survey data are of poor quality as the most appropriate unit of measurement may often be at the individual farm level. Key aspects of these indicators are their complementarities with all other indicators. The interactions between farm management systems, policies and environmental outcomes are not well developed, while identifying suitable data sets and better co-ordination of data collection methods are also needed.

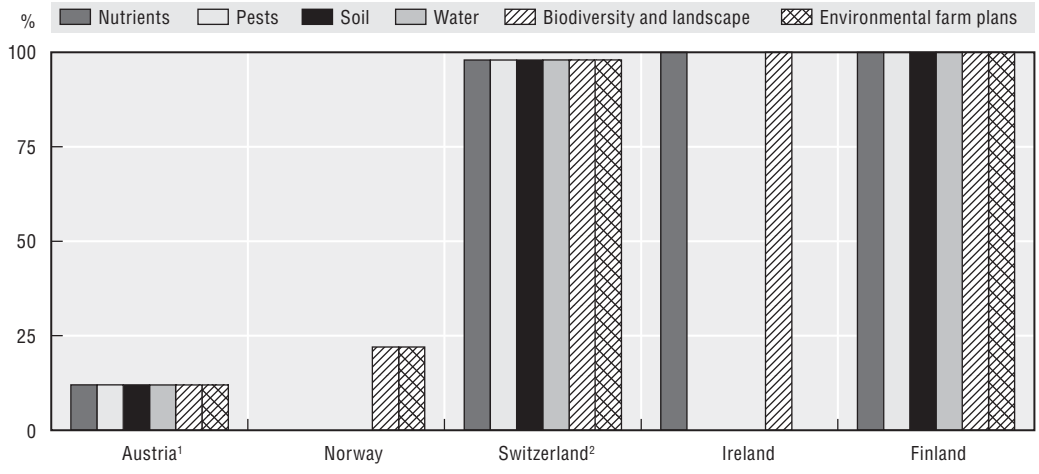
Methods to integrate social factors (*e.g.* agri-environmental education) in the design of these indicators are needed if farm management indicators are to be better integrated into policy and projection models, and be more effectively used in evaluating the economic and environmental costs of changes in farming practice. One example of this is farmer education. Some countries have developed indicators to reveal the extent to which farmers have participated in agri-environmental education programmes in the early 2000s (Figure 2.11; EEA, 2005).

2.3. Overall assessment

This section provides an overall assessment of the common themes that emerge from the review of indicators listed in this chapter, supported by background information in Annex 2.A2. The assessment is intended to identify the areas of research that could be strengthened if they are to make a contribution to providing policy makers with analytical and monitoring tools on the impact of agriculture on the environment.

Figure 2.11. **Share of farmers participating in agri-environmental education programmes**

Early 2000s



StatLink http://dx.doi.org/10.1787/288662011751

1. Estimated data for 2000-02.
2. The share is 98% for all categories.

Source: OECD (2005).

OECD has identified a number of general criteria which agri-environmental indicators need to meet, including that indicators should be (OECD, 2001):

- ***policy relevant*** – address the key environmental issues faced by governments and other stakeholders in the agriculture sector;
- ***analytically sound*** – based on sound science, but recognising that their development involves successive stages of improvement;
- ***measurable*** – feasible in terms of current or planned data availability and cost effective in terms of data collection; and
- ***easy to interpret*** – communicate essential information to policy makers and the wider public in a way that is unambiguous and easy to understand.

Policy relevant: The indicators covered in this chapter could be broadly divided into two main groups in terms of their policy relevance across OECD countries. ***First***, those AEIs that are of policy relevance across most OECD countries, although as yet neither the methodology nor the data are sufficiently advanced to develop comprehensive cross country time series indicators. This group covers indicators of: soil erosion, soil organic carbon and soil biodiversity (Section 2.2.1); water use and water quality (Section 2.2.2); biodiversity (Section 2.2.3); and farm management (Section 2.2.5). The ***second*** group of indicators are of policy relevance to a smaller group of countries and cover the indicators related to landscape and land ecosystem functions (Section 2.2.4). Annex 2.A2 identifies the extent to which countries are developing quantitative and/or qualitative information for the indicators examined in this chapter, based on member country replies to the OECD agri-environmental questionnaire.

Analytically sound: Although indicators should provide an accurate and scientifically rigorous reflection of the actual situation, it is sometimes a difficult task in developing certain types of indicators. For example, in the case of farm management indicators, the links between farming activities and biodiversity are complex and not fully understood.

This is also an issue in the case of soil biodiversity and environmental farm management practices, where the lack of consistent methodologies as well as the underlying data are major obstacles in developing these indicators. The degree to which the indicators are analytically sound across OECD countries (from high to poor) is identified in Annex 2.A2, but it should be emphasised that for some indicators this is variable. For example, the habitat-species matrix analytical methodology is well developed in Canada but other countries are beginning to explore the possibilities of how such a matrix could be developed for their country.

Overall, the Expert Meetings identified the following needs to strengthen the analytical basis of AEIs: developing scientific and socio-economic knowledge underlying AEIs; improving consistency and transparency in methods used to collect, process and interpret data; reporting indicators at a spatially appropriate level, in order to provide effective analysis and in order to discover "false" relationships, which will also include the better integration of data from local to national data sets; and ensuring that social factors (*i.e.* human and community development) are better integrated into analysis of agri-environmental outcomes.

Measurable: The collection of appropriate data available across regional as well as national boundaries involves the development and widespread adoption of appropriate data collection methods. This may include survey techniques, such as questionnaires; distribution of standardised spreadsheets for data collection; and co-operation with other international organisations that have developed databases for the relevant indicator areas. This not only concerns the quantity and quality of data collected, but also reflects the methodologies used to derive the indicators. In many of the OECD Expert Meetings, it was argued that individual OECD country approaches should strive for greater uniformity of data used across countries. Reinforcing this view, the work on some of farm management indicators shows that available data are often of poor quality, and that measurability requires reliable data that are derived from spatially and temporally appropriate levels. Annex 2.A2 shows for the countries that have replied to the OECD questionnaire whether data is already regularly collected to measure the indicator or at the other extreme if data collection systems for the indicator are still under construction.

Overall, the Expert Meetings identified the following needs to strengthen the measurability of AEIs: identifying suitable data sets, collected through surveys and census; taking into account the different degree of uncertainties among indicators when presenting data and indicator outputs to encourage appropriate use of the information; and seeking more intensive verification of data to ensure accuracy.

Easy to interpret: Indicators need to be as unambiguous as possible so that it is clear what the data and trends mean. This is particularly important for some types of indicators, such as the agri-biodiversity area as comprehensive knowledge about the interactions between farming activities and biodiversity is not yet fully developed (Section 1.8, Chapter 1; OECD, 2003c). A similar issue can be seen in the soil-biodiversity area where in the Expert Meeting, experts noticed that a particular challenge for this indicator area is to identify interpretable indicators (OECD, 2003a). Although Annex 2.A2 attempts to identify from the indicators that exist across countries to what extent they are easily interpreted (from very easy to poor) this task is difficult especially for many of these indicators which are still at an early development stage.

Overall the Expert Meetings identified the following needs to strengthen the ease of interpreting AEIs: improving knowledge (analysis) of the cause and effect relationships between agricultural systems, policies and environmental outcomes, to better serve the needs of decisions makers, including individual farmers, the farming and agro-food industry, governments and other stakeholders (*e.g.* environmentalists and consumers); and developing methods that can better integrate improved indicators into policy and projection models.

Finally, the importance of national and international agencies concerned with developing and collecting data to calculate agri-environmental indicators was stressed at the OECD Expert Meetings in terms of:

1. improving co-ordination of data collection techniques and efforts within OECD countries and between international agencies, taking into account farmer survey and census fatigue, and the costs of data collection;
2. encouraging OECD countries to invest more in agri-environmental education and promotion of awareness of those who provide data (the farmers) and those who process and interpret data (the policy makers and evaluators both at the national and international level);
3. considering the costs of collecting the primary data to calculate indicators; and,
4. fostering receptive conditions for the use of indicators by decision makers at all levels, from the farm to the international level.

ANNEX 2.A1

*Agri-environmental Indicators of Regional Importance and/or under Development**

Theme	Indicator title	Indicator definition (trends over time for all indicators)
I. Soil	***i.* Soil erosion**	1. Area and share of agricultural land affected by tillage erosion in terms of different classes of erosion, *i.e.* tolerable, low, moderate, high and severe.
		2. Contribution (as a share or physical quantity) of agriculture to off-farm sediment flows into the landscape and water bodies (from water, wind and other erosion sources).
		3. Gross on-farm soil erosion, measured through integrating models of wind, water and tillage erosion.
		4. On-farm and off-farm economic costs from soil erosion.
	***ii.* Soil organic carbon**	5. Total soil organic carbon in agricultural land.
II. Water	***iii.* Water use**	6. A net agricultural groundwater balance, where information is available, to take into account both agricultural withdrawals and recharge of groundwater.
		7. The annual share of rivers/lakes where agricultural water extraction results in rivers/lakes falling below a (seasonal) minimum reference level.
		8. The impact of agricultural water use on ecosystem health (*e.g.* wild species and wetlands).
		9. Average value of irrigated agricultural product(s) per unit of irrigation water consumed (or alternatively water withdrawn or licensed water allocation, where the water withdrawn could be the *gross* value of total water withdrawn or the *net* value of total water withdrawn minus the value of water returned to rivers and lakes and recharged to groundwater).
		10. Charges for water supplies to farmers relative to water supply charges for other major users (industry and urban).
	***iv.* Water quality**	11. Salt concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas.
		12. Pathogen (faecal indicator or pathogenic bacteria) concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas.
		13. Share of pathogen contamination derived from agriculture in surface waters and groundwater.
III. Climate change	***v.* Greenhouse[1] gases**	14. Net agricultural greenhouse gas emission balance (*i.e.* emissions less sinks).
IV. Biodiversity	***vi.* Genetic resource diversity**	15. Number and share of national native crop varieties (*i.e.* cereals, oil crops, root crops, fruit and vegetables) that are considered to be at risk of extinction (*i.e.* critical or endangered risk status).
	***vii.* Wild species diversity**	16. Number of ecologically indicative wild species using agricultural land.

* All of the indicators listed in this annex are those for which either methodologies and/or data sets are not yet at a stage that allows for representative comparative OECD country coverage or in certain cases (*e.g.* cultural landscape indicators and water retaining capacity) are only policy-relevant to some OECD countries, as shown in this chapter.

Theme	Indicator title	Indicator definition (trends over time for all indicators)
	viii. **Ecosystem (habitat) diversity**	17. Quality and quantity of habitat features (*e.g.* patch size, linear features and networks,) and their spatial composition (*e.g.* fragmentation, vertical structures, mosaics) across agricultural land.
	ix. **Linkages between habitats and species**	18. *Habitat-Species Matrix*, linking changes in the area and management of all agricultural habitat types on wild species (flora and fauna) through data from either explicit field observation or indirect information (*e.g.* expert knowledge).
		19. *Natural Capital Index*, the product of the quantity of agricultural habitat types and their quality in terms of wild species abundance, richness, habitat structure and management, measured between the current state of the agro-ecosystem and a baseline state.
V. Landscape and land ecosystem functions	***x.*** **Landscape**	20. Landscape Structure: land use, cover, patterns and cultural features (*e.g.* hedges and historic farm buildings).
		21. Landscape Functions: recreation (*e.g.* accessibility; cultural identity, tranquillity, and ecosystems (see biodiversity).
		22. Landscape Values: monetary value of agricultural landscapes (*e.g.* calculated through methods such as contingent valuation).
	xi. **Land ecosystem functions**	23. Water retaining capacity, quantity of water that can be retained in the short term, in agricultural soil, as well as on agricultural land where applicable (*e.g.* flood storage basins) and by agricultural irrigation or drainage facilities.
		24. Water retaining capacity by agricultural irrigation or drainage facility, to reveal extent to which on-farm water storage facilities retain water (*e.g.* on farm dams, dykes, canals, etc.).
		25. Landslide mitigation index, proportion of managed agricultural land within the agricultural land area subject to landslide risk.
VI. Farm management	***xii.*** **Environmental farm management plans**	26. Number (area) and share of farms (agricultural land area) under environmental farm management plans.
	xiii. **Nutrient management**	27. Number and share of farms (agricultural land area) using nutrient balances.
	xiv. **Pest management**	28. Number and share (agricultural land area) of farms with appropriate storage/handling/cleaning and disposal facilities for treatment of pesticide wastes (*i.e.* packaging and unused pesticides).
	xv. **Soil management**	29. Number and share of farms where soil biophysical properties are monitored as part of the soil test programme and/or used as land management decision support tool.
	xvi. **Water management**	30. Area and share of agricultural land that is drained.
	xvii. **Landscape management**	31. Number (area) and share of farms (agricultural land area) under public and private schemes committed to natural and cultural landscape maintenance and enhancement.
	xviii. **Farm management capacity**	32. Number and share of farmers participating in agri-environmental education programmes.
		33. Expenditure on agri-environmental management research and extension as share of total agricultural budgetary expenditures on research and extension.
VII. Agricultural inputs	***xix.*** **Energy**[2]	34. Total amount of energy contained in key agricultural inputs.
		35. The energy efficiency of agricultural production is the monetary value of annual agricultural production per unit of energy directly consumed by agriculture to produce that annual agricultural production.
		36. Production and use of renewable energy by agriculture.

1. See Box 1.7.1, Section 1.7.3, Chapter 1.
2. See Section 1.4, Chapter 1.

Source: OECD (2007).

ANNEX 2.A2

A Qualitative Assessment of the Agri-environmental Indicators included in Annex 2.A1 according to the OECD Indicator Criteria

Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
i. **Soil erosion** 1. Area and share of agricultural land affected by tillage erosion	+++	++	+	++	Soil erosion and soil biodiversity (OECD, 2003a)	Belgium, Canada, Norway, Switzerland, United Kingdom	+++
2. Contribution of agriculture to off-farm sediment flows	+++	+	+	+		Belgium, Czech Republic, Greece, Norway, Switzerland	+++
3. Gross on-farm soil erosion, measured through integrating models of wind, water and tillage erosion	++	+	+	+		Netherlands, Switzerland, United States	+
4. On-farm and off-farm economic costs from soil erosion	+++	++	+	+++		United States	+++
ii. **Soil organic carbon** 5. Change in total soil organic carbon in agricultural land over time	+++	+	+	+++	Soil organic carbon (OECD, 2003b)	Belgium, Canada, Finland, France, Ireland, New Zealand, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States	+++
iii. **Water use** 6. A net agricultural groundwater balance, where information is available, to take into account both agricultural withdrawals and recharge of groundwater					Water use and water quality (OECD, 2004b)		
7. The annual share of rivers/lakes below a minimum reference level	+++	+	+	+++		Japan, United Kingdom	++
8. The impact of agricultural water use on ecosystem health	+++	+	+	+		Japan, Korea, United Kingdom, United States	+

Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
9. Trend in the average value of irrigated agricultural product(s) per unit of irrigation water consumed	++	+	+	+		Korea, Netherlands, United States	+++
10. Charges for water supplies to farmers relative to water supply charges for other major users (industry and urban)	+++	++	++	++		Australia, Austria, Canada, Finland, France, Greece, Hungary, Korea, Netherlands, Portugal, Slovak Republic, Spain, Turkey, United Kingdom	+++
***iv.* Water quality** 11. Salt concentrations in surface waters and groundwater in excess of national water threshold values	+++	++	+	+++	Water use and water quality (OECD, 2004b)	France, Greece, Netherlands, Slovak Republic, Turkey	+++
12. Pathogen concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas	+++	++	+	+++		Denmark, Finland, France, Ireland, Korea, Netherlands, New Zealand, Norway, Switzerland	+++
13. Share of pathogen contamination derived from agriculture in surface waters and groundwater	+++	++	+	+++		Canada, Denmark, Ireland, Netherlands, Switzerland	++
***v.* Greenhouse gases** 14. Net agricultural greenhouse gas emission balance	+++	+	+	+++	No expert meeting or questionnaire response	Canada, Switzerland	+++
***vi.* Genetic resource diversity** 15. Number and share of national native crop varieties that are considered to be at risk of extinction	+++	++	+	++	Biodiversity (OECD, 2003c)	Austria, Luxembourg, Slovak Republic, Switzerland	++
***vii.* Wild species diversity** 16. Number of ecologically indicative wild species using agricultural land	++	+	+	++	Biodiversity (OECD, 2003c)	Canada, Czech Republic, Denmark, Finland, Korea, Netherlands, Switzerland	+

Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
***viii.* Ecosystem (habitat) diversity** 17. Quality and quantity of habitat features and their spatial composition across agricultural land	++	++	+	++	Biodiversity (OECD, 2003c)	Denmark, Finland, Germany, Greece, Italy, France, Japan, Korea, Netherlands, Norway, Portugal, Sweden, Switzerland, United Kingdom	+
***ix.* Linkages between habitats and species** 18. Habitat – species matrix	+++	+	+	++	Biodiversity (OECD, 2003c)	Canada, Finland	+++
19. Natural capital index	++	++	+	+		Netherlands	+++
***x.* Landscape** 20. Landscape structure	+++	+	+	++	Landscape (OECD, 2003d)	Denmark, Finland, France, Germany, Greece, Italy, Japan, Korea, Netherlands, Norway, New Zealand, Portugal, Sweden, Switzerland, United Kingdom	
21. Landscape functions	++	+	+	+		Denmark, Finland, Korea, Netherlands, Switzerland	+
22. Landscape values	++	+	+	++		Denmark, Finland, France, Greece, Japan, Korea, Netherlands	++
***xi.* Land ecosystem functions** 23. Water retaining capacity (WRC)	++	++	+	++	Land conservation (OECD, 2004c)	Greece, Italy, Japan, Korea	++
24. Water retaining capacity by agricultural irrigation or drainage facility (WF)	++	++	++	++		Greece, Italy, Japan, Korea, Slovak Republic, United Kingdom	++
25. Landslide mitigation index (LMI)	++	+	+	++		Hungary, Japan	++

Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
xii. **Environmental farm management plans** 26. Number (area) and share of farms (agricultural land area) under environmental farm management plans	+++	+++	++	+++	Farm management (OECD, 2004d)	Austria, Belgium, Canada, Czech Republic, Finland, Germany, Hungary, Ireland, Japan, Korea, Netherlands, New Zealand, Norway, Slovak Republic., Switzerland, United Kingdom	++
xiii. **Nutrient management** 27. Number and share of farms (agricultural land area) using nutrient budgets	+++	+++	+	+++	Farm management (OECD, 2004d)	Ireland, Japan, New Zealand, Norway, Switzerland	+++
xiv. **Pest management** 28. Number and share (agricultural land area) of farms with appropriate storage/handling/cleaning and disposal facilities for treatment of pesticide wastes	+++	+	+	++	Farm management (OECD, 2004d)	Belgium, Finland, Norway, New Zealand, Switzerland	++
xv. **Soil management** 29. Number and share of farms where soil biophysical properties are monitored as part of the soil test programme and/or used as land management decision support tool	++	+	+	+	Farm management (OECD, 2004d)	Austria, New Zealand, Switzerland	+
xvi. **Water management** 30. Area and share of agricultural land that is drained	+	+	+	+	Farm management (OECD, 2004d)	Belgium, Czech Republic, Finland, Germany, Greece, Hungary, Netherlands, Norway, Slovak Republic, Turkey	++
xvii. **Landscape management** 31. Number (area) and share of farms (agricultural land area) under public and private schemes committed to natural and cultural landscape maintenance and enhancement	++	++	++	++	Farm management (OECD, 2004d)	Austria, Belgium, Korea, Netherlands, Norway, Switzerland, United Kingdom	+++
xviii. **Farm management capacity** 32. Number and share of farmers participating in agri-environmental education programmes	++	+	+	++	Farm management (OECD, 2004d)	Austria, Finland, Ireland, Norway, Switzerland	++

Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
33. Expenditure on agri-environmental management research and extension as share of total agricultural budgetary expenditures on research and extension	++	+	+	++		Korea, Norway, Sweden	+++
***xix.* Energy**[5] 34. Trends in the total amount of energy contained in key agricultural inputs	+	+	+	+		Switzerland	++
35. The energy efficiency of agricultural production is the physical (monetary) value of annual agricultural production per unit of energy directly consumed by agriculture to produce that annual agricultural production	++	+	+	++		Canada, Switzerland	++
36. Production and use of renewable energy by agriculture	+++	+++	++	+++		Many OECD countries	+++

The notation for each criterion is as follows: +++ = very good/strong; ++ = average; + = poor.

1. For a full definition of each indicator see Annex 2.A1.
2. For a discussion of each criterion see Section 2.3 of this chapter.
3. This column indicates at which OECD Agri-environmental Indicator Expert Meeting the indicator was discussed. see Bibliography for a list of these meetings.
4. This column shows which countries are developing the indicator, quantitatively and /or qualitatively, based on member country replies to the unpublished OECD Agri-environmental Indicator questionnaires The column also reveals the extent to which the indicator is comparable across countries.
5. Energy indicators are from an unpublished OECD consultant's paper.

Source: OECD (2007).

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Chapter 3

OECD Country Trends of Environmental Conditions related to Agriculture since 1990

BACKGROUND TO THE COUNTRY SECTIONS

Structure

This chapter provides an analysis of the trends of environmental conditions related to agriculture for each of the 30 OECD member countries since 1990, including an overview of the European Union, and the supporting agri-environmental database can be accessed at *www.oecd.org/tad/env/indicators*. Valuable input for each country section was provided by member countries, in addition to other sources noted below. The country sections are introduced by a figure showing the national agri-environmental and economic profile over the period 2002-04, followed by the text, structured as follows:

- ***Agricultural sector trends and policy context:*** The policy description in this section draws on various OECD policy databases, including the *Inventory of Policy Measures Addressing Environmental Issues in Agriculture* (*www.oecd.org/tad/env*) and the Producer and Consumer Support Estimates (*www.oecd.org/tad.support/pse*).
- ***Environmental performance of agriculture:*** The review of environmental performance draws on the country responses to the OECD agri-environmental questionnaires (unpublished) provided by countries and the OECD agri-environmental database supporting Chapter 1 (see website above).
- ***Overall agri-environmental performance:*** This section gives a summary overview and concluding comments.
- ***Bibliography:*** The OECD Secretariat, with the help of member countries, has made an extensive search of the literature for each country section. While this largely draws on literature available in English and French, in many cases member countries provided translation of relevant literature in other languages.

At the end of each country section a standardised page is provided consisting of three figures. The first figure, which is the same for every country, compares respective national performance against the OECD overall average for the period since 1990. The other two figures focus on specific agri-environmental themes important to each respective country.

Additional information is also provided for each country on the OECD agri-environmental indicator website (see address above) concerning:

- Details of national agri-environmental indicator programmes.
- National databases relevant to agri-environmental indicators.
- Websites relevant to the national agri-environmental indicators (*e.g.* Ministries of Agriculture)
- A translation of the country section into the respective national language, while all 30 countries are available in English and French.

Coverage, caveats and limitations

A number of issues concerning the coverage, caveats and limitations need to be borne in mind when reading the country sections, especially in relation to making comparisons with other countries:

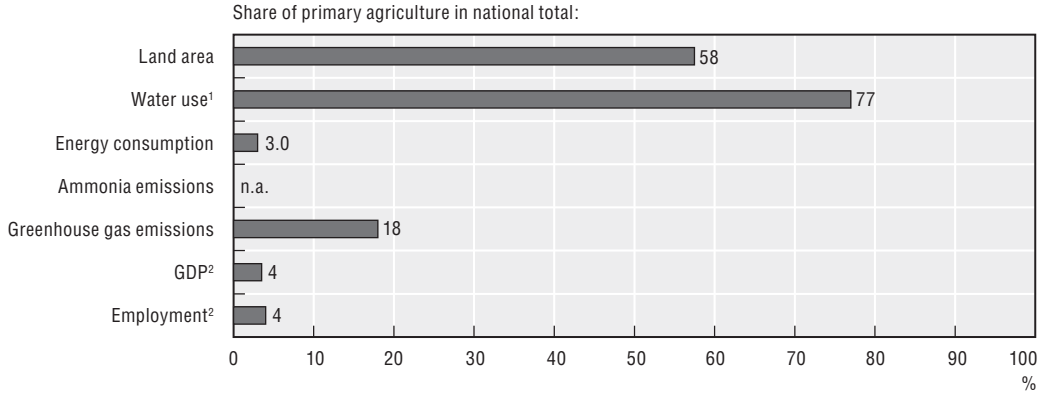
Coverage: The analysis is confined to examination of agri-environmental trends. The influence on these trends of policy and market developments, as well as structural changes in the industry, are outside the scope of these sections. Moreover, the country sections do not examine the impacts of changes in environmental conditions on agriculture (*e.g.* native and non-native wild species, droughts and floods, climate change); the impact of genetically modified organisms on the environment; or human health and welfare consequences of the interaction between agriculture and the environment.

Definitions and methodologies for calculating indicators are standardised in most cases but not all, in particular those for biodiversity and farm management. For some indicators, such as greenhouse gas emissions (GHGs), the OECD and the UNFCCC are working toward further improvement, such as by incorporating agricultural carbon sequestration into a net GHG balance.

- ***Data availability, quality and comparability*** are as far as possible complete, consistent and harmonised across the various indicators and countries. But deficiencies remain such as the absence of data series (*e.g.* biodiversity), variability in coverage (*e.g.* pesticide use), and differences related to data collection methods (*e.g.* the use of surveys, census and models).
- ***Spatial aggregation*** of indicators is given at the national level, but for some indicators (*e.g.* water quality) this can mask significant variations at the regional level, although where available the text provides information on regionally disaggregated data.
- ***Trends and ranges in indicators***, rather than absolute levels, enable comparisons to be made across countries in many cases, especially as local site specific conditions can vary considerably. But absolute levels are of significance where: limits are defined by governments (*e.g.* nitrates in water); targets agreed under national and international agreements (*e.g.* ammonia emissions); or where the contribution to global pollution is important (*e.g.* greenhouse gases).
- ***Agriculture's contribution to specific environmental impacts*** is sometimes difficult to isolate, especially for areas such as soil and water quality, where the impact of other economic activities is important (*e.g.* forestry) or the "natural" state of the environment itself contributes to pollutant loadings (*e.g.* water may contain high levels of naturally occurring salts), or invasive species that may have upset the "natural" state of biodiversity.
- ***Environmental improvement or deterioration*** is in most individual indicator cases clearly revealed by the direction of change in the indicators but is more difficult when considering a set of indicators. For example, the greater uptake of conservation tillage can lower soil erosion rates and energy consumption (from less ploughing), but at the same time may result in an increase in the use of herbicides to combat weeds.
- ***Baselines, threshold levels or targets for indicators*** are generally not appropriate to assess indicator trends as these may vary between countries and regions due to difference in environmental and climatic conditions, as well as national regulations. But for some indicators threshold levels are used to assess indicator change (*e.g.* drinking water standards) or internationally agreed targets compared against indicators trends (*e.g.* ammonia emissions and methyl bromide use).

3.1. AUSTRALIA

Figure 3.1.1. **National agri-environmental and economic profile, 2002-04: Australia**



StatLink http://dx.doi.org/10.1787/288667861547

1. Data refer to the year 2000.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.1.1. Agricultural sector trends and policy context

Growth in agricultural production is among the most rapid across the OECD, with the volume of production growing by 23% between 1990-92 to 2000-04 (Figure 3.1.2). However, partly due to deteriorating terms of trade, agriculture's role in the economy has remained stable over the past 10 years with regard to its contribution to GDP. Agriculture is a vital sector in the Australian economy contributing about 4% to GDP, 4% to employment and accounting for around 25% of merchandise exports (2004) (Figure 3.1.1). Around two-thirds of agricultural production is exported. Australia exports 95% of wool produced, 65-75% of beef, sugar and wheat and 50-60% of sheep meat, wine and dairy [1].

Despite harsh environmental conditions, agriculture is the most extensive form of land use. Fundamentally agriculture is based on extensive pastoral and cropping activities. However in recent years the farming sector has increasingly diversified into intensive livestock and horticultural industries. Agricultural activity occurs on around 60% of the total land area (2002-04). Livestock grazing accounts for 57% of land use in Australia, whilst dryland agriculture accounts for 5% [2]. Recent structural changes, developments in water and natural resource management, access to new biotechnologies and climate, are significantly impacting on agricultural productivity, land use and land use intensity. The average farm size increased by 23% whilst the number of farms fell by 25% since 1990. This has resulted in a –5% decline in area of land under agricultural production, between 1990-92 and 2002-04 [1]. Some 70% of arable farmers have adopted both direct drilling and minimal tillage practices and productivity in the sector has increased annually by 2.3% over the period 1974/75 to 2004/05 [3].

Support to the agriculture sector is among the lowest in the OECD. Producer support fell from 8% in the mid-1980s to 4% by 2002-04 (as measured by the OECD's Producer Support Estimate) compared to the OECD average of 30%. The decrease in producer support was the result of deregulation of several agricultural sectors such as, dairy, wool, pork and egg industries. Most support is provided through budget financed programmes, regulatory arrangements and tax concessions [4].

A range of policies have been implemented to address agri-environmental concerns. Soil salinity, acidity and erosion are key issues being addressed through various programmes including the *National Landcare Programme* (NLP), the *National Action Plan for Salinity and Water Quality* (NAP) and the *National Heritage Trust* (NHT). The NAP encourages regional action to tackle salinity problems and together with the NHT are funding measures to address salinity, amounting to AUD 33 (USD 21) million in 2003-04. The *National Landcare Programme* (NLP), which involves over 40% of landholders (who manage 60% of the land) (Figure 3.1.3), promotes sustainable management practices, and includes undertaking conservation and improving the productivity, profitability and condition of natural resources [5, 6]. The Federal Government has committed AUD 160 (USD 120) million over 2004-08 for the NLP. Funding of AUD 18 (USD 14) million is available under the *Environmental Management Systems* programme to improve farm management [7]. An AUD 50 (USD 38) million *Environmental Stewardship Programme* is helping farmers, among others, to preserve and restore high-end environmental assets under a new long-term stewardship programme on their properties. The NHT, jointly with states and territories, is also funding a range of strategic programmes aimed at the sustainable use of natural resource by agriculture.

The relationship between agricultural production and the environment is recognised in the broader framework of policies aimed at improving environmental outcomes. The *National Strategy for Ecologically Sustainable Development* provides the framework for most environmental and natural resource policies and the funding to states/territories to enact legislation supporting national strategies. The NAP aims to reverse salinity and water quality problems, with funding of AUD 1.4 (USD 1.0) billion over 2000-08, while the NHT focuses on biodiversity and sustainable natural resource management, with funds of AUD 1.3 (USD 0.9) billion over 2004-08 and a further AUD 2 (USD 1.5) billion over five years from 2008-09 [8]. The National Water Initiative (NWI) seeks to increase productivity and efficiency of water use, sustain rural and urban communities, and ensure the health of river and groundwater systems. Under the NWI funding of AUD 2 (USD 1.5) billion is provided for programmes, which include irrigators, to move toward full cost recovery for water, expand trade in water, improve access entitlements, plan for environmental needs, and enhance water management [9].

The Greenhouse in Agriculture and Regional Australia Programme is building capacity in agriculture and land management to reduce greenhouse gas (GHG) emissions. In addition, taxation policies affect energy production and use by agriculture. In 2004, the Federal Government committed AUD 20.5 (USD 15) million over four years to help agriculture and land management sectors to reduce GHG emissions. A further AUD 1 (USD 0.7) million has been contributed, along with AUD 1.25 (USD 0.9) million from livestock industry partners, to a project to reduce agriculture's methane emissions. The ***Greenhouse Challenge Plus for Agriculture*** is a voluntary programme promoting emissions reductions at enterprise level. Farmers are provided rebates for on-farm diesel use, equal to nearly AUD 650 (USD 480) million of budget revenue forgone in 2004-06. The Federal Government has set a production target for fuel ethanol and biodiesel from renewable sources to contribute to

about 1% of the consumption of transport fuels by 2010. Biofuels (both domestically produced and imported) are subject to lower excise taxes compared to fossil based fuels, while producers of biofuels are provided tax exemptions and investment grants, such as under the *Biofuels Capital Grants Programme*. Under the 2005 *Renewable Remote Power Generation Program* AUD 206 (USD 151) million is being granted up to 2012 to off-grid energy users, including farmers, covering 50% of the capital cost of installing renewable energy equipment, which could reduce GHGs.

3.1.2. Environmental performance of agriculture

Australia has recognised the need to address a number of land and water management issues in which farming plays a key part [2, 3, 10]. Three issues are important to agriculture's relationship with the natural environment: soil resources, water resources, and biodiversity. Estimates suggest that management of these issues costs AUS 3.5 (USD 2.5) billion annually [11], or 10% of agricultural GDP. Farmers are estimated to have invested in natural resource management and environmental protection (mainly on fencing, earthworks and weed management) AUD 220 (USD 140) million in 1999-2000, or about AUD 2.60 (USD 1.65) for every AUD dollar invested by the government [12]. A large share of farmed soils are naturally shallow, acidic, low in fertility, high in salt, have low water holding capacity and require careful management to avoid degradation.

Soil conservation and management is a major national issue [2]. While soil degradation occurs naturally some farming practices have exacerbated the problem, with, on average across Australia, 20% of farmland showing acute degradation [10]. Evidence over the 1990s, however, suggested some improvement in soil quality [5, 11, 13]. For example, farming practices in certain areas have improved the fertility and health of soils through: the use of fertilisers; lime to reduce soil acidity; and minimum tillage techniques [2]. ***On-farm costs*** of degradation from soil acidity, sodicity and salinity were estimated in 2000 at AUD 2.6 billion (USD 1.5 billion) [14] (about 7% of agricultural GDP), with most farmers reporting these problems as having a significant impact on their businesses [5], especially in Western Australia [15]. Soil degradation is also leading to ***off-farm damage*** on a national scale, from agriculture and non-agricultural sources, especially from dryland salinity and soil erosion, by degrading aquatic environments, raising drinking water treatment costs, and damaging buildings and roads [13].

Soils are naturally predisposed to salinity due to climatic and topographical factors, but past land clearing and management have contributed to increased soil salinity in some regions. Recent estimates suggest that about 2 million hectares of farmland show some signs of salinity [2]. As the problem of salinity evolves slowly with time lags of 50-100 years, the area at high risk may triple between 2000 and 2050 [16]. By 2002 two-thirds of irrigated farms had changed practices to address salinity, including tree planting, fencing and building banks, levees and drains [17]. Accelerated ***soil erosion*** above natural rates is relatively evenly distributed across Australia, but while grazing land has typically erosion rates 2-5 times natural rates, for croplands rates are 5-20 times higher [18, 19]. While erosion rates on cropping lands are in some areas higher, the area of land involved is significantly smaller. About 20% of farmers report that erosion has a major impact on their business [5], but the off-farm impacts can be significant. Some 120 000 km of rivers have degraded riparian vegetation, with the restoration cost estimated at AUD 1.2 (USD 720) billion [18], reinforcing the importance of policies in place to manage impacts on water quality. Also 90% of soil sediment reaching estuaries are derived from 20% of

catchments, with the greatest concern for sediment flows into the Great Barrier Reef, a UNESCO World Heritage Site [12, 19]. ***Soil acidity*** is estimated to affect about half of the total agricultural land area, at a level probably affecting crop yields [2]. While the application of lime could remedy the problem and is used in cropping systems, this is financially not viable for many pasture-based industries [2]. Run-off from disturbance of coastal ***acid sulphate soils***, including by agriculture, have had an adverse impact on aquatic ecosystems, in some areas of North New South Wales and Queensland [20]. Enhanced management practices indicate that some improvement in the problem of acid sulphate soils is underway [21].

The expanding demand for water resources, including from agriculture, is an issue of national significance. The growth in use of water by agriculture (24%) was more than double that of other users (9%) over the period 1993-95 to 2000, when annual average rainfall levels have declined in major farming areas (Figure 3.1.2) [16]. Nationally 26% of river basins and 30% of aquifers are close to or exceed sustainable extraction limits [10]. Many irrigators in the Murray-Darling Basin (MDB) have switched from surface water to groundwater since the surface water cap on withdrawals was introduced in 1995. In combination with other groundwater uses and the drought, this has caused groundwater to decline over large areas of the MDB [2]. A key driver in the growth of water demand has been the 17% rise in irrigated area over the period 1990-92 to 2001-03, with farming accounting for three-quarters of total water use in 2000 (about 90% of which is used by irrigators), although data for 2001-02 suggest agriculture's share in total water use was 69% [3]. Irrigators produce about 25% of total agricultural gross value of production [2]. There has been considerable improvement in water use efficiency by irrigators, with water application rates declining from 8.7 megalitres/hectare of irrigated land (ML/ha) in 1996-97 to 4.3 ML/ha in 2002-04, with around 40% of water applied by technically efficient irrigation technologies (Figure 3.1.2) [2, 22]. Almost a third of water used by agriculture is for irrigating pasture, especially for dairy cows, with sugar cane and cotton accounting for a further 25% [22].

Agriculture is one impact, among others, on water quality for some rivers and coastal waters. In river basins in the most populated areas of Australia, nutrients and soil turbidity are the most widespread pollutants from agriculture amongst other sources, followed by salinity, acidity/alkalinity, with pesticides and biological contaminants having a lower occurrence [23]. About two thirds of river basins were found in 2000 to have nutrients in excess of acceptable standards or were excessively turbid, while water quality exceeded salinity standards in over a third of river basins [3, 23]. Salinisation is also affecting drinking and irrigation water quality, with some surface water in Western Australia too saline for domestic use [10], while rising groundwater levels which contain salt are damaging urban infrastructures in parts of New South Wales [16]. Groundwater in intensively farmed areas of north eastern Australia show only 3% of wells with nitrate concentrations above drinking water standards [24].

The quality of water entering the Great Barrier Reef (GBR) is of concern. Water quality entering the GBR has declined affecting about 25% of its area, partly as a result of farm pollutants, although phosphorus run-off from urban sewerage is also a problem [26, 26]. The dry tropical regions in Queensland are the main source of these pollutants, although some farmers are adopting practices to reduce pollution. While evidence of adverse impacts on the GBR from pollutants is not conclusive, research suggests the need for caution for any activities leading to elevated pollution levels [25].

Environmental pressure from agricultural nutrients and pesticides are very low compared to most OECD countries, however, input use has grown with the large increase in the volume of agricultural production over the period 1990-92 to 2002-04 (Figure 3.1.2). With an overall decline in livestock numbers, much of the growth in ***nutrient surpluses*** is from greater use of fertilisers, especially nitrogen. Overall efficiency of nitrogen use (*i.e.* ratio of nitrogen crop uptake to total nitrogen inputs) is low [27] and below the OECD average although higher for phosphorus. Increased soil nutrient testing over the 1990s may improve nutrient efficiency [27], although management of manure ponds on dairy farms is poor [28]. Nearly 19 000 tonnes of total phosphorus and 141 000 tonnes of total nitrogen were estimated to be transported down rivers to the coast from areas of intensive agricultural activity [2].

Pesticide use volume increased by 10-15% annually over the period 1996-99, of which about 40% is accounted for by glyphosate (a herbicide) used in conservation farming and minimum tillage techniques that reduce soil erosion. More recent pesticide use data are unavailable and there is little monitoring of the environmental impacts of pesticides [29]. There was a shift in the late 1990s from broad spectrum, relatively toxic pesticides, to use of targeted and less harmful ones [29]. In the cotton growing areas of Eastern Australia only 10% of samples from surface water exceeded drinking water standards for pesticides [29], and 50% of the land cultivated to cotton is grown under best management practice codes [16]. The cotton industry has also made significant steps to reduce pesticide use through growing genetically modified cotton varieties and using other improved practices (Figure 3.1.4) [2, 29, 30]. An environmental audit of the sugar industry, however, reveals only a small share of farmers using Integrated Pest Management practices [31].

Trends in air emissions from agricultural sources have revealed mixed results over the past decade. Agriculture is the major source of ***ammonia emissions***, but time series emissions data are unavailable [32]. However, given nitrogen surpluses rose slightly over the period 1990-92 to 2002-04 (mainly due to higher fertiliser use, as overall livestock numbers have declined), it is possible ammonia emissions and acidifying air pollutants have also risen slightly. As a signatory to the *Montreal Protocol*, Australia agreed to phase out by 2005 the use of ***methyl bromide*** for purposes other than for quarantine and pre-shipment use, agreed critical uses where no technically or economically viable alternatives are available, and feedstock uses. By 2004 methyl bromide was reduced by over 70% from the 1991 baseline level. "*Critical Use Exemptions*" (CUE) were sought in 2005 and following years, and agreed for certain uses, which under the *Protocol* allows farmers additional time to find substitutes. In 2005, methyl bromide use was reduced a further 10% compared to the 1991 baseline level. With some methyl bromide users ceasing use in 2007, but rice, strawberry growers and cut flower producers have exemptions for use up to, and including 2008. Rice and strawberry growers are currently seeking to continue use under CUE status after 2008 [33]. Both these latter industries are undertaking research, together with the Federal Government, into alternative chemicals and/or application methodologies.

Greenhouse gas emissions (GHGs) from agriculture accounted for 16% of Australia's net GHG emissions in 2004, and 18% of gross emissions over 2002-04 [2]. Projections to 2010 suggest that agricultural GHGs could be 5% above their 1990 level, without taking into account possible savings from soil sequestration and land use changes, although estimates of these savings are still subject to a high degree of uncertainty [34]. ***Soil carbon levels*** vary annually, but results from the Australian Greenhouse Office, based on long term nationally consistent modelling, suggest that as a result of clearing for agriculture soil carbon has declined from slightly above 675 million tonnes in 1990 to about 643 million tonnes

in 2004 [2]. The growth in agricultural gross GHG emissions was 6% between 1990-92 and 2002-04, compared to a reduction of 3% across the OECD area, while total Australian gross GHG gross emissions rose by 22% (Figure 3.1.2). The growth in agricultural GHG emissions was largely driven by increases in the application of fertilisers and manure to soils, intensive savannah burning, and clearance of land under native vegetation for agricultural use, although the rate of clearance has decreased [35]. Use of ***agricultural biomass*** for bioenergy is at present contributing, in the case of biofuels, less than 0.1% of transport fuel use [2, 37]. Agriculture's ***direct on-farm consumption of energy*** rose by nearly 50% over the period 1990-92 to 2002-04 (the Australian Bureau of Statistics [3], calculate an increase of 35% over the period 1990 to 2002), almost twice the rate of growth in national energy consumption over this period, although agriculture accounted for only 3% of total energy consumption in 2002-04 [37].

Agriculture is one source of pressure on biodiversity, but there are signs of the pressure easing [2]. Conserving biodiversity is a serious environmental challenge, especially given Australia's world "megadiversity" status [3, 38]. But while farming contributes to pressure on biodiversity other pressures are also important, including invasive species, urbanisation, mining and climate variability. ***Clearing of native vegetation*** for agricultural and other land use purposes has been one of the main threats to terrestrial biodiversity. Over the last 20 years state/territory governments have tightened land clearing controls and in 2004 all Australian governments agreed to phase out broadscale land clearing by the end of 2006 [39]. These changes have seen a reduction in land clearing, with flow on benefits to the environment. The rate of clearance (forest conversion and reclearing of land previously cleared) was nearly 30% between 1990 and 2004, with about 325 000 hectares of conversion and reclearing in 2004 [3]. While from 2007 all land clearing has been prohibited, there can be long time lags between land clearance and future adverse ecological impacts [40].

Agricultural pressures on wild species reductions have been significant in the past but more recently the pressures have eased. Almost 30 mammal and bird species over the past 20 years showed significant reductions in farming areas, especially where land has been cleared [2, 41], or overgrazed [2, 42]. For aquatic biodiversity conditions in rivers and coastal environments have been modified by environmental disturbances, including farming [2]. All sources of environmental disturbances combined, have resulted in over 30% of total river length degraded from reduced riparian vegetation, and nutrient and sediment loadings, while 50% of inland waterbirds are listed as vulnerable or threatened mainly from habitat loss [43]. Nationally nearly 10% of wetlands are affected by salinity [38, 44]. A number of reports have identified agriculture as one of the main sources of pollution threatening some coastal habitats, especially the GBR [25, 26].

3.1.3. Overall agri-environmental performance

Agriculture's environmental footprint remains significant. This can contribute to lowering farm productivity (*e.g.* due to soil degradation, low nutrient efficiency), and also causing much larger off-farm costs. Of particular concern have been the clearing of native vegetation and water use by agriculture, contributing to pressures on the quality and availability of water for environmental purposes. However, there is now a trend in reducing land clearing. Problems of agricultural pollution from nutrients and pesticides and soil erosion are more regional, while methyl bromide use has declined, likely to have increased slightly for agricultural ammonia emissions, but showing a slight rise for agricultural GHG emissions.

Australia has built a natural resource management programme, largely through the Australian Government's *Natural Heritage Trust* and its funding of regional natural resource management groups. Investment plans produced by regional groups require both environmental outcome and environmental performance monitoring and reporting through *State of the Environment* reports and other mechanisms [2, 8, 13, 45, 46]. Addressing information gaps will improve the ability to track environmental performance and evaluate policies, as the paucity of relevant time series data sets has inhibited the development of more effective responses [2, 12]. Key areas where monitoring could be improved are: regular assessment of soil erosion [2]; water pollution, in particular, measuring pesticide and other agricultural discharges into coastal waters [2]; and tracking changes in biodiversity, [43]. The Australian Greenhouse Office is developing a new reporting procedure for on-farm emissions to improve measurement of methane and nitrous oxide emissions from agriculture.

Australian agriculture will continue to face challenges with regards to the environment. But these challenges need to be understood in the context of the difficult "natural environmental" conditions in which Australian farmers operate relative to many OECD countries, in terms of: high levels of risk from natural climatic hazards and climate variability (*e.g.* drought, floods, fire) [3, 47, 48]; domination of soils of "naturally" low fertility, poor water holding capacity, and easily degraded; and existence of invasive non-native species imposing costs on both farmers and the environment.

The ongoing decline of soil quality is a concern, as are inefficiencies in the use of other resources by agriculture. Despite lack of definitive data it is clear that soil acidity, salinity, soil erosion and nutrient loss all remain a major threat to the long term sustainability of agriculture [2]. Also livestock grazing, while providing high economic value for agriculture, continues to place heavy pressure on the environment, especially in some sensitive areas [2]. Taking action to raise the efficiency of nitrogen use in crop and livestock agriculture would bring production, greenhouse and environmental benefits [48]. Moreover, subsidising farm diesel energy costs is a disincentive to improving energy use efficiency and reducing GHGs.

The country also has a major challenge in terms of biodiversity conservation given its world mega-biodiversity status, and agricultural pressures from land clearing and grazing pressures [3]. There has been considerable progress since 1990 in terms of reducing land clearance by agriculture, especially with the prohibition of broad-scale vegetation clearing from 2006 [3]. Nevertheless, past declines in vegetation extent and condition, as well as fragmentation of habitats and continued grazing pressures on some habitats, especially in sensitive areas, are cause for ongoing action and vigilance [2]. Moreover, there are concerns that rivers and associated aquatic ecosystems in tropical Australia could come under increasing pressure as sources of water to support irrigation development in southern Australia are subject to enhanced climate variability [2].

There has been ongoing adaptation in the approach of agricultural and environmental policies over the past 10 years, from a mainly farm focus to a more integrated and long term emphasis operating at water catchment and regional levels [49]. Many farmers are addressing environmental concerns, with Government initiatives, such as the NLP, raising farmer awareness and responses to these issues, with over 40% of farmers in *Landcare* groups (Figure 3.1.3) [49, 50]. Agricultural practices, that have in the past exacerbated natural erosion rates, are improving, with the NLP encouraging more sustainable practices.

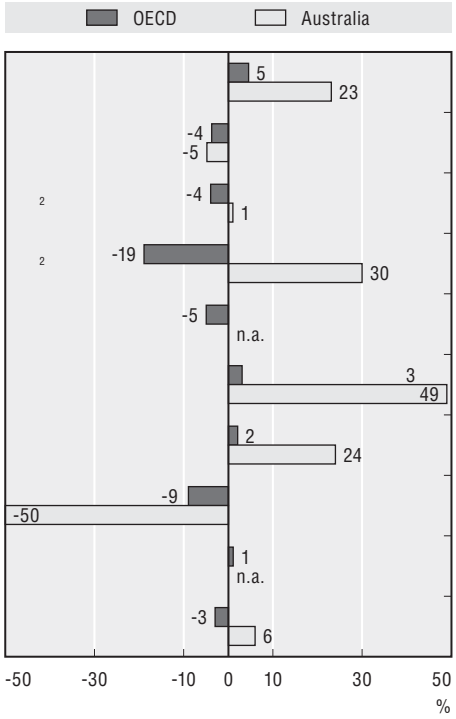
A range of government supported initiatives are being led by industry to address the environmental footprint of agro-chemical use. For example, the NLP is funding delivery of *FertCare*, through the fertiliser industry, to encourage farming practices that manage environmental risks of fertiliser use. Increased funding of the NAP to control soil salinity, such as through revegetation, is leading to secondary beneficial impacts on biodiversity and reducing GHGs [42]. Between 1996-2004 the NHT facilitated nearly 800 000 hectares of land rehabilitation which, together with state/territory government controls on land clearing and the NHT *Bushcare Program*, should help biodiversity conservation.

While increasing attention is being paid to water management, recent droughts have placed additional pressures on an already stressed water system [2]. For water some issues that need addressing include, among others: variation between States in water reforms and securing adequate water for environmental purposes; exploring new opportunities for water recycling; and improving irrigators water use efficiency [4, 9, 51, 52]. Uncontrolled and unsustainable growth in groundwater use in many regions, linked to the stress on surface water systems, is a cause for serious concern [2]. There are, however, some positive signs of more sustainable use of groundwater use by irrigators, for example in the Great Artesian Basin many bore holes have been capped, drainage canals covered and some wetlands restored [2].

Water reform policies are beginning to change farming systems. This is evident with farmers producing products with higher economic returns (*e.g.* from pasture to horticultural crops), increasing efficiency of irrigation and by diverting water for environmental purposes to encourage biodiversity conservation [2]. Further improvements in agricultural water use are needed. Some are being delivered through provision of technical advice to irrigators under initiatives such as the *National Program for Sustainable Irrigation through Land and Water Australia*. In 2007, the Federal Government allocated an additional AUD 10 (USD 7.5) billion under the *National Plan for Water Security*. Improving the efficiency of agricultural water use is a key objective of the Plan through reforms in the management of water access and trading, and improved irrigation practices, in the industry.

Figure 3.1.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

Variable	Unit		Australia	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	123	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–22 364	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	17	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	1	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	n.a.	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+659	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+3 276	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	4.3	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	n.a.	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	+5 374	–30 462

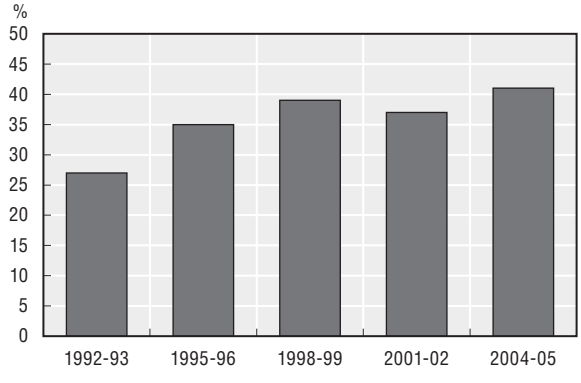
n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

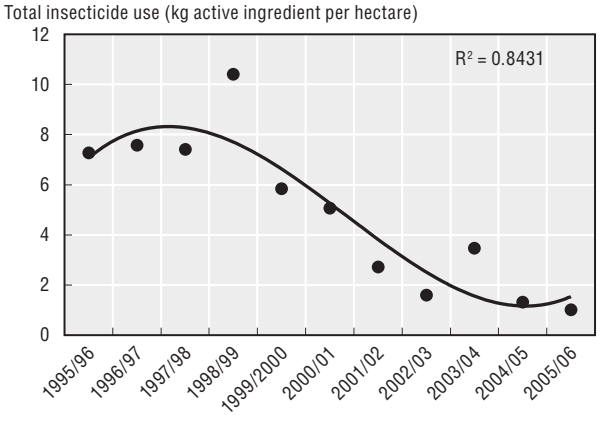
Figure 3.1.3. **National Landcare membership**

% of total number of farmers



Source: Australian Bureau of Agricultural and Resource Economics.

Figure 3.1.4. **Annual quantities of insecticide and acaricide applied to the cotton crop**



Source: Cotton Research and Development Corporation, Australian Government.

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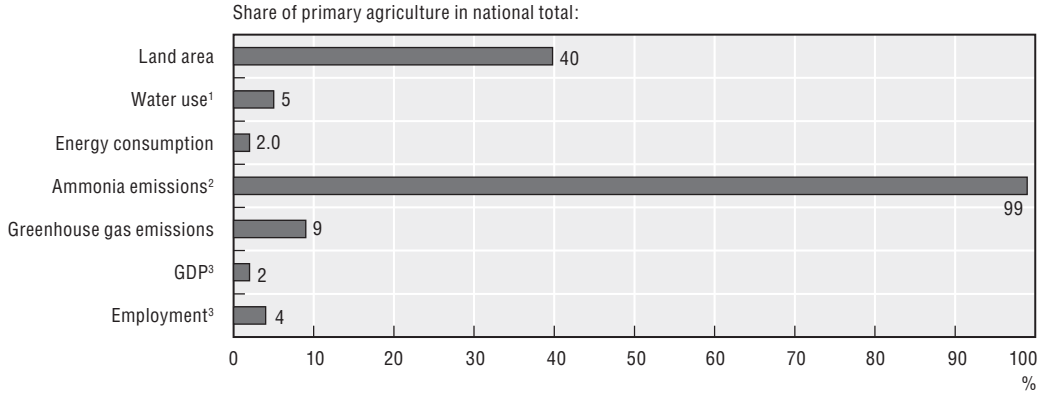
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3.2. AUSTRIA

Figure 3.2.1. **National agri-environmental and economic profile, 2002-04: Austria**



StatLink http://dx.doi.org/10.1787/288706230083

1. Data refer to the year 2003.
2. Data refer to the period 2001-03.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.2.1. Agricultural sector trends and policy context

Agriculture's role in the economy is small and declining, currently accounting for under 2% of GDP and about 4% of employment [1, 2] (Figure 3.2.1). Agricultural productivity has been increasing with a 10% rise in the volume of production from 1990-92 to 2002-04 while the area farmed fell by 3% (Figure 3.2.2). Although there has been some expansion in arable output, much of the increase in production has occurred through growth in livestock output, especially output from milk production. The livestock sector accounts for over 55% of the total value of agricultural output [1, 2].

The intensity of production diminished significantly over the period 1990-92 to 2002-04 [3], as revealed by the expansion in agricultural production relative to the reduction in purchased farm input use. This fell by around –40% and –20% for phosphate and nitrogen inorganic fertilisers respectively, –24% for pesticides, and –13% for direct on-form energy consumption (Figure 3.2.2). The reduction in farm chemical use reflects, in part, the near doubling of organic farming as a share of the total agricultural area over the past decade, reaching over 10% by 2005, among the highest in the OECD. There was a tenfold rise in the number of organic farms since the early 1990s to about 20 000 by 2003 [4]. Over 60% of farmland is pasture, much of which is in mountainous areas where most farms are classified as disadvantaged [2].

Farming is mainly supported under the Common Agricultural Policy, but also through national expenditure within the CAP framework. Support to EU15 agriculture declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate) compared to the OECD average of 30% [5]. Nearly 70% of EU15

farm support is output and input linked, but this share was over 98% in the mid-1980s. In addition to EU support, the total Austrian agricultural budget was EUR 954 (USD 1200) million in 2004 or 18% of agricultural gross value added [5]. About 20% of public farm research funding is directed towards agri-environmental concerns.

Agri-environmental measures seek to promote extensive farming practices, biodiversity and landscape conservation. These measures are included under the Austrian Agri-environmental Programme (ÖPUL) established in 1995 [4, 6]. ÖPUL accounts for nearly a third of the agricultural budget [7], providing about EUR 4000 (USD 4520) per farm in 2003. Farmers are compensated for imputed loss of farm income due to constraints on production (*e.g.* lower livestock numbers), rather than as a function of direct environmental benefits [3]. ÖPUL is a voluntary programme, which includes 32 measures covering six payment categories. These measures often feature advisory services for farmers and inspections to monitor compliance with, for example: organic farming, non-application of pesticides and fertilisers, crop rotation, extensive cereal production and extensive grassland [1, 4, 6]. Farmers already participating in ÖPUL are eligible for additional payments if they undertake such actions as converting arable land to pasture, keeping green cover over winter and maintaining nutrient accounts [3]. About 14% (EUR 86-USD 110 million in 2004) of ÖPUL funding is provided for organic farming [3, 5]. However, as organic farms can participate in other ÖPUL measures (for example, by preserving cultivated areas through mowing of steep areas), the share of premiums paid to agricultural holdings engaged in organic farming accounts for 24% of the ÖPUL budget. Support is also given for *in situ* conservation of endangered plant varieties and livestock breeds [8].

Agriculture also plays a key role in the national strategy for sustainable development, and is affected by national taxation policies and international environmental agreements. While the *Water Act* already included various measures to reduce agricultural nutrient loads, it was reformed following entry into the EU in 1995 (including abolition of a fertiliser tax [9, 10],) and replaced by the EU *Nitrate Directive*. The *Nitrate Action* programme of 1999 includes specific policies aimed at reducing nitrate emission from agriculture, including bans on manure application during the winter and use of good agricultural practices such as buffer zones along rivers and maximum limits on fertiliser application [4]. From 2005 support for on-farm diesel fuel, through tax refunding, are equivalent to between EUR 40 and 50 (USD 50-60) million of budget revenue forgone annually [5, 11].

Agriculture is affected by international environmental agreements with respect to limiting emissions of: ammonia (*Gothenburg Protocol*); methyl bromide (*Montreal Protocol*); and greenhouse gases (*Kyoto Protocol*). As part of its *Kyoto Protocol* commitments about EUR 20 (USD 25) million annually is provided as support for biomass and farm forestry, under the *Federal Environment Fund* and the *Agricultural Biomass Fund*, to promote renewable energy production and improvements in energy efficiency [3]. Support to electricity generation from renewable resources, including biomass, is provided through: feed-in tariffs which provide above market prices to renewable power; and a requirement that electricity suppliers must meet a certain minimum share of supplies from renewables [12].

3.2.2. Environmental performance of agriculture

Agriculture uses over 40% of the total land area so it has a significant impact on the environment. Two key environmental issues concern agricultural water pollution, especially from nutrients and pesticides, and the interaction of farming with biodiversity and cultural landscapes. Other environmental issues of importance to agriculture include soil erosion, mainly on arable and permanent cropland, and ammonia and greenhouse gas emissions.

Soil erosion remains a concern in arable cropping areas [4, 13]. About 7% of total agricultural land (35% of arable land) was classified in the late 1990s as having a moderate to severe risk of erosion (10.1-33.3 tonnes of soil/hectare/year), with a further 4% (22% of arable land) in the low erosion risk category (5-10 tonnes/hectare/year) [13]. Most soil erosion takes place on agricultural land, especially on land under maize. While water erosion is monitored, there is no national monitoring of wind erosion [13, 14, 15]. There are also no time series trends of soil erosion risk, but changes in farming practices suggest that the risk of erosion could be declining. Between 1999 and 2003 the numbers of farms using soil conservation practices (*e.g.* greening arable areas over winter, low tillage) doubled to about 75% of all farms, while over the same period the area of arable and permanent crop land with a vegetative cover throughout the year rose by 15% to a share of nearly 90% of arable and permanent cropland in 2003 (Figure 3.2.3) [16].

Extensively used grassland plays an important role for soil organic carbon (SOC) storage in farmed soils, accounting for over 40% of the total stock in 1990 [17]. It is unclear what changes in SOC stocks have occurred in agricultural soils over the 1990s, although the conversion of cropland to forest seems to have had little impact on overall storage of SOC [17].

Farming is a major source of water pollution [3, 4, 13, 18]. The main water quality problems related to agriculture are mainly situated in the crop growing areas in the east and south-east. In these regions surface water is particularly affected by enhanced phosphorus loads from agriculture, and groundwater quality is influenced by nitrate concentrations [4, 18]. Pesticide pollution is a continuing, although declining, problem [4, 18]. Despite the use of sewage sludge on agricultural land (farming recycles about 10% of total sewage sludge supplies [4]), water pollution from heavy metals by using sewage sludge in farming is generally not a problem [19].

Agricultural nutrient surpluses have shown a marked reduction between 1990-92 and 2002-04. The decrease in nitrogen (N) and phosphorus (P) surpluses (tonnes) over this period was nearly 30% and over 60% respectively, well below the average reductions for the OECD and EU15. Moreover, the intensity of nutrient surpluses per hectare of total farmland, at 48 kgN/ha and 3kgP/ha 2002-04, is also much lower than the averages for the OECD and EU15 (83 kgN/ha and 10kgP/ha respectively) (Figure 3.2.2). While there was a slight reduction in crop and pasture production leading to a lower nutrient uptake, much of the decrease in nutrient surpluses has been due to lower livestock numbers, especially dairy cattle, and a reduction in fertiliser use, partly explained by the rapid growth of organic farming.

Agricultural nutrient pollution of water has been declining, but remains a problem in some regions. In the late 1990s agriculture contributed over 30% of nitrogen and phosphorus in surface water and around 50% of nitrate in groundwater [20]. The efficiency of nutrient use (ratio of nutrient output to input) is above the OECD average and has shown a rising trend over the past 15 years. At the same time, only around 12% of farms regularly test their soil for nutrients, which is low compared with many other European OECD countries. Pollution of groundwater is a problem as it provides nearly all of Austria's drinking water [4, 18]. The drinking water threshold level for nitrate in groundwater (45 mg/l) was exceeded in 13% of all monitoring sites (including farming areas) in 2003, compared to around 20% in the early 1990s [21, 22]. Trends for nitrates found in surface waters have declined [4, 23]. Despite this improvement, some regions, especially the north-east, have seen rising nitrate and phosphorus levels in both surface and ground waters during the past decade [4, 24].

Pesticide use has declined significantly. Farming accounts for about 90-95% of total pesticide use [4]. The volume in terms of active ingredients fell by 23% from 1990-92 to 2001-02, a reduction markedly higher than the average for the OECD (–5%) and the EU15 (–4%), despite the small increase in crop production. The rapid expansion in organic farming and growth in the area under fallow, partly explain the decrease of pesticide use over this period. The area of farmland under ***organic management*** rose from just under 6% in 1993-95 to almost 10% by 2002-04, among the highest share across the OECD area (Figure 3.2.3). However, the share of the integrated pest management area in total arable and permanent crop area declined slightly from 3.8% to 3.2% between 1995 and 2003 [16]. Overall, in the late 1990s, only 0.2% of groundwater monitoring sites showed pesticide levels above the drinking water threshold (0.1 µg/l) [19]. Atrazine concentrations remained above these levels in around 3% of monitoring sites in 2005, down from about 30% in the early 1990s, although Atrazine was banned from use in 1995, and some pesticides in river water are thought to derive from transboundary sources [3, 13, 18]. About 12% of the 800 authorised pesticides have been subject to a national environmental risk assessment [13]. In recent years ***methyl bromide*** use (an ozone depleting substance) was over two tonnes annually, being largely used for nematode control in soils [4]. By 2005 under the *Montreal Protocol* Austria is committed to a total phase out of methyl bromide use. While many OECD countries have applied for exemptions with respect to methyl bromide use, Austria has not done so.

As agriculture is largely rain-fed, use of irrigation is limited. Farming accounted for around 5% of national water use in 2003, which was mainly drawn from groundwater for use by livestock producers [25, 26]. Irrigation is limited to a few areas mainly for horticultural crops and it accounts for a small share of agricultural water use (5%), while some support is provided for water deliveries to irrigators. Livestock producers pay the full cost for water deliveries [16].

Ammonia emissions from agriculture declined by 15% over the period 1990-92 to 2001-03. As other sources of acidifying emissions have decreased more rapidly (except nitrous oxide) over the past decade, however, the share of ammonia in total acidifying air pollutants rose to 37% (in acidification equivalents) by 2001 [4, 27]. Agriculture accounted for about 99% of total ammonia emissions in 2001-03, mostly from livestock manure, and by 2001-03 had reduced emissions to about 65 000 tonnes, which is equal to the 2010 target of 65 000 required under the *Gothenburg Protocol*. Critical loads for deposition of acidifying substances continue to be exceeded in 10% of ecosystems and in 50% of the most sensitive ecosystems, but this is an improvement from the early 1990s when respective shares were nearly 50% and over 90% [3].

Agricultural greenhouse gas (GHG) emissions decreased by 12% from 1990-92 to 2002-04. This reduction compares to an overall rise across the economy of nearly 15%, and a commitment under the EU *Burden Sharing Agreement* to meet the *Kyoto Protocol* to reduce total emissions by –13% in 2008-12 [28]. As a result of these diverging trends, agriculture's share of total GHGs declined to 9% by 2002-04 [28]. Much of the decrease in agricultural GHGs is due to lower livestock numbers (reducing methane emissions) but also reduced fertiliser use (lowering nitrous oxide emissions) (Figure 3.2.4). The national climate change target aims to reduce agricultural GHG emissions to 6.7 million tonnes of carbon dioxide equivalent ($mtCO_2e$) by 2010, and this compares to the level of 8.0 $mtCO_2e$ in 2002-04 [29, 30].

The agricultural sector has also contributed to lowering GHG emissions by reducing its on-farm energy consumption and by expanding biomass production, as a feedstock for renewable energy (heat, power and fuel). Direct on-farm energy consumption decreased by 13%

between 1990-92 and 2002-04 and farming only contributed 2% of total energy consumption (2002-04). Renewable energy production from agricultural and other biomass feedstocks, including farm forestry, is being rapidly expanded, with the objective of avoiding 1 million tonnes of CO_2 emissions by 2008 [31]. By 2003 biomass and biofuels contributed almost 10% of total primary energy demand [7, 21]. Biomass, including biogas, contributes about 4% of electricity produced from renewable energy sources, and around 15% to heat generation, while biodiesel production has increased more than threefold during the 1990s, to 25 000 tonnes by 2002 [4, 32].

Agriculture's pressure on biodiversity is starting to ease. But disentangling the impacts of farming activities on biodiversity is difficult due to a lack of time series data, and to a range of factors including: the continued process of intensification in fertile areas; the conversion of land in marginal farming areas, particularly high nature value Alpine pastures, to forestry; and the overall reduction of pollutants into the environment reducing pressure on biodiversity [8, 13]. In terms of ***agricultural genetic resources*** there are *in situ* programmes and extensive *ex situ* collections of plant and animal genetic material [8, 33]. Crop varieties used in production have increased in diversity. The number of national crop varieties endangered has halved over the period 1990 to 2002, linked partly to the expansion of rare crop cultivation. Most endangered livestock breeds are now under conservation programmes compared with very few in the early 1990s.

A key driving force affecting the impact of agriculture on ecosystems has been the decrease in the total agricultural land area, which declined by over 3% from 1990-92 to 2002-04. About 120 000 hectares of farmland is annually converted to other land uses, roughly a half of which is converted to urban uses, transport infrastructure and quarries, while the other half is forested [19]. A major share of the reduction in farmland has been the decline in the area of pasture, the main form of agricultural land use. Although the ÖPUL conservation programmes have slowed the rate of reduction, the tendency continues for the conversion of "high nature" value alpine pastures to fallow and forestry [4]. Nevertheless, it is apparent that an increase in some high nature value agricultural habitats has occurred under the ÖPUL programmes, while the expansion in the area under organic management is generally considered by Austrian research as beneficial to wild flora and fauna [8]. Research suggests that almost 20% of the total land area which is farmed can be regarded as national "hot-spots" of biodiversity [33].

Nationally, the decline in species is continuing, with over 60% of vascular plants endangered or threatened, 25% of mammal and bird species, with amphibians and reptiles under particular threat [3, 8]. At the same time, data on overall trends of wild flora and fauna impacted by farming activities are poor. The limited evidence concerning agriculture suggests that between 1998 and 2002 farmland bird populations declined slightly and that farming poses a threat to nearly 70% of important bird habitats through intensification and land use changes. Government research indicates that pastures and meadows are rich in diversity of different grass, herb and legume species [6].

Farmed Alpine pastures play a key role in cultural landscape amenity. Alpine pastures account for about 70% of total farmland and nearly 40% of farms, with transhumance involving half a million cows, sheep and goats annually [4]. The Alpine pastures are considered to provide benefits for biodiversity, scenic landscapes, and tourism, as well as a source of income for farmers [1]. While there has been extensive research in establishing a typology for Austrian landscapes (with 42 different landscape types identified), there is a lack of national time series data tracking physical changes in agricultural landscapes [34, 35].

3.2.3. Overall agri-environmental performance

Overall agricultural pressure on the environment has eased over the past 15 years, but there are two key developments that threaten this positive development. First, further increases in production and intensification in the more fertile eastern area of the country and, second, the conversion of land in marginal farming areas, particularly high nature value Alpine pastures, to forestry. In general agricultural pollution from nutrients, pesticides, ammonia and greenhouse gases all declined over the past decade. Even so, agriculture remains a major source of water pollution, soil erosion is a concern, ammonia emissions continue to harm ecosystems, and the conversion of Alpine pastures to forestry is a threat to biodiversity and cultural landscapes reliant on farming activities.

Agri-environmental monitoring and evaluation efforts are mixed. The monitoring of water pollution from agricultural nutrients and pesticides is well established, although not for pollution from livestock pathogens. Monitoring of ammonia and greenhouse gas emissions from agriculture has recently been improved [27, 28]. Monitoring of soil quality (*e.g.* erosion), biodiversity (except for agricultural genetic resources) and landscape change on agricultural land are inadequate, although in 2003 the Ministry of Agriculture commissioned research to improve biodiversity monitoring [4].

Agri-environmental programmes have become more widespread, with particular emphasis on promoting organic farming, and the protection of biodiversity and cultural landscapes. Almost 80% of farmers and 90% of farmland are included under the ÖPUL agri-environmental programme and Austria has one of the highest rates of uptake for agri-environmental schemes across the EU15 [36]. However, the uptake of ÖPUL is slightly lower in intensively farmed areas where ground water pollution from agriculture tends to remain a problem [19].

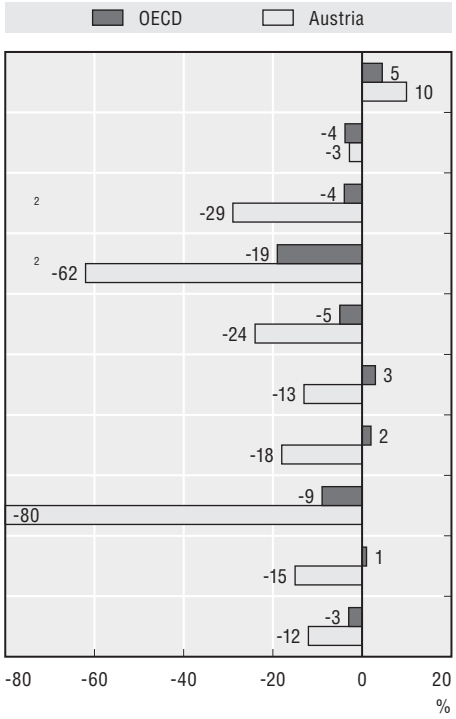
The rapid expansion of organic farming is closely linked to funding under ÖPUL, with 95% of organic farms receiving ÖPUL funding, with plans to further increase support to organic production [1, 4, 13]. The growth in organic production has partly explained the decrease in fertiliser and pesticide use, but some Austrian research suggests that organic farms are not always able to prevent nitrate leaching into groundwater [37]. Moreover, the further expansion of the organic sector is not likely to be constrained by the supply of organic produce, but by constraints on the demand side (*e.g.* lack of distribution channels, standardised labelling, and organised marketing and processing) [38]. Research suggests that the future impacts of the EU 2003 Common Agricultural Policy reforms for the environment in Austria are likely to lead to an expansion of grassland and the reduction of arable land (resulting in an increase of soil organic matter), and an overall reduction of livestock numbers (leading to lower nutrient surplus, ammonia and greenhouse gas emissions). Organic farming could further expand but there is likely to be no increase in forestation, leading to the maintenance of open agricultural landscapes [39, 40].

While pressure from farming on the environment has been reduced problems persist. Water pollution, in particular groundwater (the main drinking water source), from nutrients and pesticides remains a concern in some regions. Soil erosion exists in some arable cropping areas but changes in farming practices (increased plant cover over winter) suggest erosion rates might be falling, although there are no time series data of erosion trends. The 2010 target under the *Gothenburg Protocol* to reduce ammonia emissions has already been met (in 2001-03), but continued reduction in emissions is necessary to reduce the harmful impacts of acidification on sensitive ecosystems, especially through improving manure and fertiliser management [4]. While agricultural GHG emissions and

on-farm energy consumption have decreased over the past 15 years, further reductions might be achieved if the farm support on diesel fuel were lowered, which acts as a disincentive to lower energy use, improves energy efficiency and further reduce GHG emissions. In terms of the conservation of biodiversity in agriculture, there are concerns that only a small share (3-10%) of ÖPUL funding is directly targeted at biodiversity conservation [34]. However, other ÖPUL measures are important for biodiversity conservation, measures such as those covering preservation of cultivated areas, support for alpine grazing and herding, and organic farming too.

Figure 3.2.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

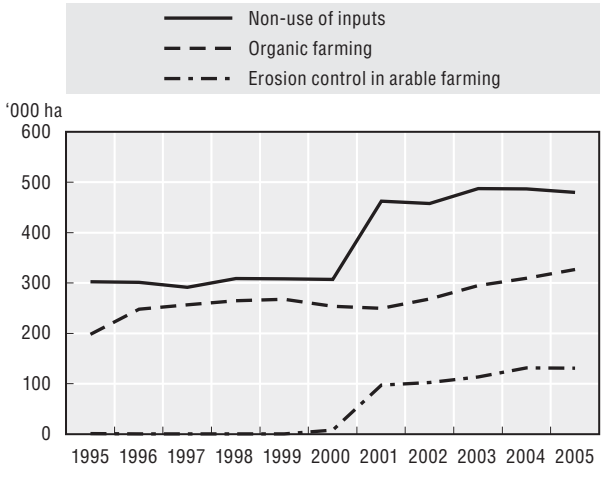
Variable	Unit		Austria	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	110	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–95	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	48	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	3	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–1 008	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–96	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–18	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	2.5	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–11	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–1 074	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

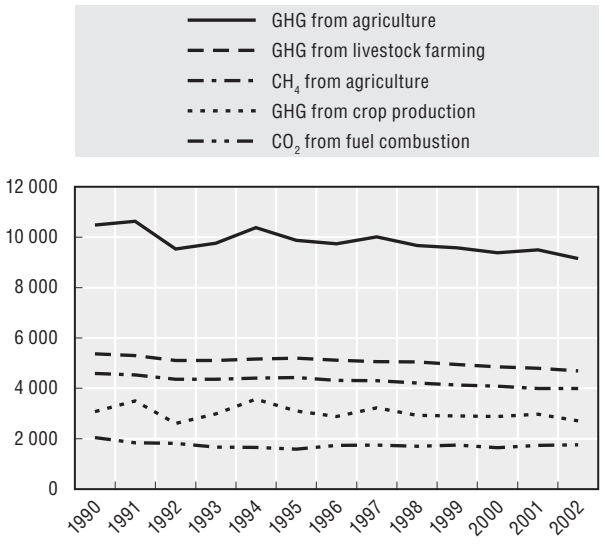
Figure 3.2.3. **Area under non-use of inputs, organic farming and erosion control measures of the ÖPUL agri-environmental programme**



Source: Federal Ministry for Agriculture, Forestry, Environment and Water Management.

Figure 3.2.4. **Greenhouse gas emissions from agriculture**

CO_2 equivalent Gg



Source: Federal Ministry for Agriculture, Forestry, Environment and Water Management.

StatLink http://dx.doi.org/10.1787/288736374800

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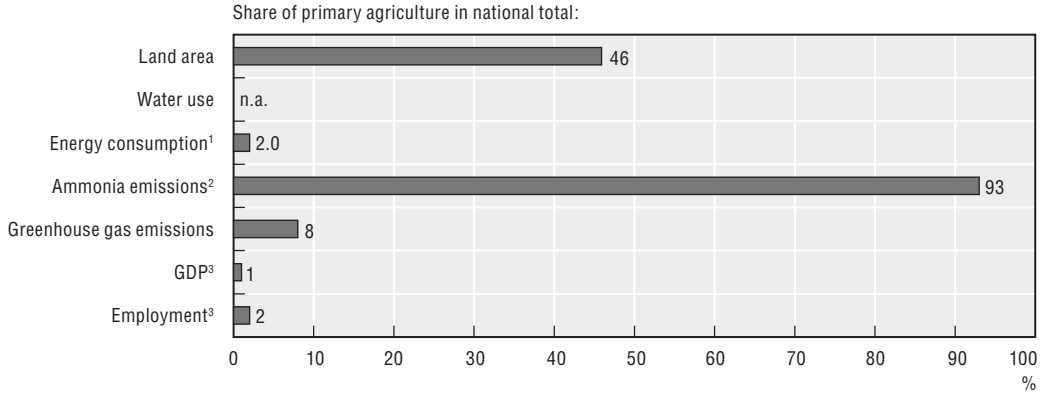
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3.3. BELGIUM

Figure 3.3.1. **National agri-environmental and economic profile, 2002-04: Belgium**



StatLink http://dx.doi.org/10.1787/288840560263

1. Data refer to the period 1999-01.
2. Data for the period 2002-04 refer to the period 2001-03.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.3.1. Agricultural sector trends and policy context

Agriculture's contribution to the economy declined over the 1990s, and by 2004 accounted for less than 1% of GDP and represented about 2% of employment [1] (Figure 3.3.1). The overall volume of farm production decreased by around 1% over the period 1990-92 to 2002-04 (Figure 3.3.2), and since 2000 production has decreased most rapidly for livestock but less so for crops. While Walloon accounts for 55% of farmland it generates only half the agricultural value added of Flanders where two-thirds of the intensive farming holdings are situated [1].

The area farmed increased by about 3% from 1990-92 to 2002-04 (Figure 3.3.2), and accounted for 45% of the total land area in 2002-04, although the area of farmland declined by nearly 1% from 2000 to 2005 [1]. The growth in farmland over the 1990s was largely because of improved measurement (*i.e.* registration and reporting by farmers), rather than an actual increase in land farmed, linked to manure policy and the CAP reforms of the early 1990s [2, 3]. Agriculture remains highly intensive by comparison with most OECD countries, although purchased farm input use per unit volume of output diminished over the period 1990-92 to 2002-04. During this period the volume of inorganic fertilisers declining by about –15% for nitrogen and over –30% for phosphorus, pesticides by 19% and direct on-farm energy consumption by –6% (Figure 3.3.2).

Farming is mainly supported under the Common Agricultural Policy, with additional national expenditure within the CAP framework. Support to EU15 agriculture declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD

Producer Support Estimate) compared to the OECD average of 30% [4]. Nearly 70% of EU15 farm support is output and input linked, falling from over 98% in the mid-1980s. Annual Belgian agricultural budgetary expenditure (less CAP payments) was EUR 222 (USD 277) million in 2004, of which around 30% EUR 65 (USD 80) million) was for agri-environmental measures, which was about 1% of farm gross value added. Since 2001 farm policy is devolved to Flanders, Walloon and Brussels, although only 3% of the Brussels region is farmed [4, 5, 6].

Agri-environmental policies are mainly focused on reducing the intensity of farming and protecting biodiversity and cultural landscapes. Flanders and Walloon have established their own agri-environmental plans [6, 7, 8]. While there are many common elements in these plans, they accounted for 23% of the agricultural budget in Flanders and 45% in Walloon in 2004 [4]. Nutrient policy under the EU *Nitrates Directive* was implemented in Flanders in 1991, with obligatory requirements for manure application and storage and voluntary codes of good environmental farm practice. Since 2004 there have been obligatory requirements for nutrient application and storage, and soil cover during winter [2, 7] in Walloon. Payments have been provided for biodiversity and landscape conservation since 2000, such as maintaining hedges, ponds and meadow birds, and also to reduce nutrient application rates [2, 6, 9].

Agriculture is impacted by national environmental and taxation policies and international environmental agreements, with national environmental policies devolved to the regions in the early 1990s [6]. Revenue from environmental taxes was about 2% of GDP in 2003, including taxes on manure surpluses, groundwater use [10] and, since 1997, on five of the most common pesticides found in water at EUR 2.5 (USD 3.1)/kg [2]. Under measures to manage and recycle packaging waste, farmers are required to recover at least 80% of their pesticide packaging or they are subject to a tax of EUR 0.124 (USD 0.155)/litre of pesticide [2]. Farmers are exempt from fuel tax [11], while tax reductions were granted on biofuels from 2005 [12], and tax benefits are available to farmers if they invest in energy saving (13.5% tax deduction on the energy saving investment) [1]. Some international environmental agreements require Belgian agriculture to reduce nutrient pollution into the North Sea (*OSPAR Convention*), ammonia emissions (*Gothenburg Protocol*), methyl bromide (*Montreal Protocol*) and greenhouse gases (*KyotoProtocol*) [13].

3.3.2. Environmental performance of agriculture

The high population density and intensive farming system exert great pressure on the environment. The key environmental challenges are to reduce water pollution from farm nutrients, pesticides and heavy metals, as well as to maintain soil quality, reduce ammonia and greenhouse gas emissions, and enhance biodiversity and cultural landscapes [8, 14].

Soil erosion is a concern in some regions, although less than 1% of farmland area is experiencing water erosion greater than 11 tonnes per hectare per year. Problems related to wind erosion are minor. Some improvement in soil management practices (*e.g.* low tillage, green cover during winter) is helping to raise soil quality, especially in those regions (central areas) at greatest risk of erosion both on and off-farm [2, 15, 16]. Improvements in soil management practices together with land use changes may also have increased soil organic carbon levels over the 1990s, thus, improving soil fertility and carbon sequestration in soils, although current evidence suggests such improvements are likely to have been small [2, 8, 17, 18].

The pressure from farming activities on water quality is easing, but absolute levels of agricultural nutrient and pesticide pollution of water remain amongst the highest in the OECD. Agriculture is the major source of nutrient pollution of water, with water pollution from pesticides and heavy metals also important [8, 14].

Agricultural nutrient surpluses decreased between 1990-92 and 2002-04, but surpluses per hectare of farmland remain amongst the highest in the OECD (Figure 3.3.2). Over this period surpluses (tonnes) of nitrogen fell by –26% and phosphorus by –43%, mainly because of a reduction in fertiliser use and higher uptake of nutrients due to an expansion in crop production, although this was partly offset by an increase in livestock numbers (largely pigs and poultry) [14, 19]. As a result livestock now accounts for the major share of nutrient surpluses (notably dairy cattle). The drop in fertiliser use has become decoupled from the growth in crop production over the past decade, although the intensity of fertiliser use remains high in relation to the OECD average [13]. The efficiency of nutrient use (volume ratio of inputs to outputs) is below the OECD average, but overall has improved over the period 1990-92 to 2002-04 [20, 21]. The improvement in nutrient use efficiency is partly because of the obligation of all farms to implement a nutrient management plan since the early 1990s, with an increasing number of farms now undertaking soil nutrient testing.

Agriculture accounts for the major and growing source of nutrients and heavy metals in water, as pollution from other sources (industry, urban) is declining [14, 22]. The shares of ***nitrogen and phosphorus*** from agriculture in surface waters in the Flanders region were about 60% and 35% respectively, compared to respective shares of 50% and 25% in 1992 [14, 22]. Similar levels are apparent for coastal waters, which rose from 39% and 14% for nitrogen and phosphorus respectively in 1985, to respective shares of 56% and 39% by 2000 [2]. The share of surface water monitoring sites in agricultural areas of Flanders exceeding drinking water standards in 2001-02 for surface water was about 40% for nitrates and phosphorus and 30% for nitrates in groundwater. Nitrate concentrations are also rising in certain aquifers in Walloon [8]. Despite the decrease in agricultural nitrogen surpluses, pollution of groundwater is not expected to improve for many years because of the time lags involved in the transfer of nitrates through water tables [2, 7], with even longer time lags for phosphorus.

Agricultural pollution of surface water from heavy metals, especially fertilisers, is making a growing contribution to total emissions, as heavy metal pollution from non-agricultural sources is rapidly declining [8, 14]. In Flanders, however, targets for heavy metal emissions in surface water are being met in most cases [14]. This is mainly because of lower inorganic fertiliser use and the ban on applying sewage sludge as a fertiliser (although sewage sludge use is restricted in Walloon) [18].

Environmental risks have diminished with the 19% reduction in the volume of pesticide use (active ingredients) over the period 1990-92 to 2001-03 (Figures 3.3.2 and 3.3.3). Agriculture accounts for around 70% of pesticide use, with horticultural producers being the major users [23]. Pesticide use has become decoupled from the growth in crop production, mainly because of the increasing use of new generation pesticides, which in general are applied at a much lower dose per hectare, and improvements in pest management practices [23]. But despite the increase in the area under integrated pest management (IPM) over the past decade this only accounted for under 2% of the total arable and permanent crop area, with organic farming accounting for 3% of the total agricultural land area in 2003. For some crops the share under IPM is higher, such as for apples (23%) and pears (33%) [24]. In Flanders 11% of surface water monitoring sites in agricultural areas recorded that atrazine (a pesticide)

was found in excess of drinking water standards in 2002, with a share of 25% for groundwater monitoring sites, but this varies regionally from 13% to 32% [2]. An environmental pesticide risk indicator for aquatic species declined by in excess of 100% during the period 1990 to 2004, well in excess of the target set by the Flemish government to achieve a 50% reduction between 1990 and 2005 [14].

Farming accounts for a minor share of water use despite significant growth in the area irrigated. The area irrigated grew by 67% between 1990-92 and 2001-03, but accounts for less than 2% of total farmland (3% of arable and permanent cropland), and 22% of total agricultural water use. Most of the irrigated area is in the Flanders region, and is mainly used for irrigating horticultural crops [2]. Over 80% of the water used on irrigated areas is applied using efficient water application technologies, such as drip emitters and low pressure sprinklers [2].

Agricultural ammonia and methyl bromide emissions have declined over the past decade. Having increased slightly over the period 1990 to 1997, agricultural ***ammonia*** decreased sharply from 1998 to 2002, largely because of the obligatory requirement for low emission spreading of manure (Figure 3.3.2). Agriculture accounted for over 93% (2001-03) of ammonia emissions, and the lowering of emissions has contributed to the overall reduction in emissions of acidifying substances by nearly 30% between 1990 and 2002, although the level of acidification continues to damage ecosystems [8, 14]. While there has been a substantial reduction in the use of ***methyl bromide*** (an ozone depleting substance) it continues to be used by the horticultural sector [14, 25]. Belgium, as a signatory to the *Montreal Protocol* agreed to phase out methyl bromide use by 2005, but also agreed under the Protocol to "*Critical Use Exemption*" of 36 tonnes (ozone depleting potential) or about 10% of its consumption level in 1991, which under the Protocol allows farmers additional time to find substitutes [25].

Agricultural greenhouse gas emissions (GHGs) declined by 10% between 1990-92 and 2002-04, but rose by 1% for other sectors of the economy (Figures 3.3.2 and 3.3.4). This compares to a commitment as part of the *Kyoto Protocol* to reduce total GHGs by 7.5% in 2008-12 under the EU GHG *Burden Sharing Agreement*, relative to the 1990 base period [1]. Much of the decrease in agricultural GHGs was due to lower fertiliser and livestock numbers, with farming contributing 8% of total GHG emissions in 2002-04 and 2% of total energy consumption. ***Carbon sequestration*** related to agriculture showed a small increase over the period 1990 to 2004, mainly due to improvements in soil management practices (low tillage practices) and reafforestation of farmland, to some extent offset by land use changes, especially the increase in arable and permanent cropland [17, 18]. The potential of agricultural to provide biomass feedstock for renewable energy production is limited at present as there is no biofuel production capacity [26].

Agriculture has adversely impacted on biodiversity since 1990, but there are recent signs since around 2000 that this pressure could be easing. The key pressures derive from eutrophication and acidification of ecosystems due to surplus nutrients, desiccation from farmland drainage and groundwater extraction, and the fragmentation and conversion of farmland to non-agricultural uses [27]. For ***agricultural genetic resource diversity*** an increasing number of crop varieties and livestock breeds (except cattle) have been used in production in Flanders since 1990. Some endangered cattle breeds, however, are maintained under *ex situ* conservation programmes, and a regional network of *ex situ* fruit orchards to conserve local fruit varieties was established in 2005. There are also some improvements for *in situ* collections of crops and livestock genetic material [28].

Trends in species diversity showed that farming accounts for over 70% of the harmful impacts affecting the quality of important bird areas. Compared to other EU countries there has been a high rate of decline in farmland birds. Within Flanders ten species showed a negative trend, especially the Skylark (*Alauda arvensis*) and Meadow Pipit (*Anthus pratensis*), and two a positive trend from 1985 to 2002 [2, 29]. The acidification and eutrophication of terrestrial and aquatic ecosystems from excess agricultural nitrogen emissions in Flanders currently threaten 40% of the floral species that are not tolerant to acid conditions. Over 70% of species rich grasslands exceeded the critical load for nitrogen in 2003, although pressure on habitats from nitrogen pollution declined over the 1990s [14, 29]. Butterfly populations have been negatively affected by excess nitrogen in the environment as well as the conversion of extensive pasture to other uses [27, 30]. Concerning ***agricultural habitat diversity***, conversion of small farmland habitats, such as ditches and hedgerows, has also been a major cause of the loss of certain flora, for example the Primrose (*Primula vulgaris*) [27, 31]. Moreover, wild species have been adversely impacted since 1990 by the conversion of pasture to cropland, and to a lesser extent permanent crops (horticultural crops), and the conversion and fragmentation of farmland to other uses, especially urban use and forestry [29].

Agriculture plays a key role in changing cultural landscapes [5]. There are landscape inventories, but no regular monitoring of changes in agricultural cultural landscapes. But concerns remain, however, that cultural landscapes are being adversely impacted by fragmentation, as a result of the enlargement of field size and the expansion of urban areas and transport networks [5].

3.3.3. Overall agri-environmental performance

Overall the high intensity of farm input use exerts considerable pressure on the environment, although since the late 1990s there have been signs the pressure could be easing. Pressure on the environment has largely become decoupled from farm production with the reduction in output over the period 1990-92 to 2002-04 less than the much larger decline in purchased input use. But absolute levels of many agricultural pollutants in Belgium remain high relative to average OECD standards, and as a result the sector is a major source of water and air pollution, while farming practices continue to cause pressure on soil erosion, biodiversity and cultural landscapes.

Each Federal region is developing its own agri-environmental monitoring and evaluation system. As a consequence of the shift to a regional decision making system, obtaining a uniform assessment and data for Belgium as a whole is difficult and, hence, there is little co-ordinated information available at a national level [5, 27]. Both Flanders and Walloon publish annually environmental indicators, including many of relevance to agriculture [8, 14, 29], and in 2004 Flanders made a detailed study of agri-environmental performance [32].

Agri-environmental measures have been considerably strengthened and expanded since 2000, compared to those measures first introduced in the early 1990s [6, 9]. In 2003 around 10% of the agricultural land area was under agri-environmental schemes [6, 9], with the major part of expenditure under these schemes being aimed at reducing nutrient pollution (water and air) [6, 9]. Recent policy initiatives, including budgetary payments, have led to a substantial expansion in agricultural areas under biodiversity conservation (*i.e.* field margins, ponds, hedges, extensive grassland), even so they only covered just

over 1% of farmland in Flanders in 2004 [29]. Payments to convert and maintain organic farming were increased in 2003, for a minimum period of 5 years [4]. The target area organically farmed is set to rise from 3 % of farmland in 2003 to 10% by 2010 [2, 9, 28].

Despite recent improvements in agri-environmental performance major challenges remain. Flanders has identified a 2010 target for ***nutrient surpluses*** (70 kg N/ha and 4 kg P/ha) to protect drinking water quality, but this will require a major effort to achieve, as the surpluses in 2002-04 were 184 kg N/ha and 23 kg P/ha [14]. Similar concerns also arise in overcoming farm nitrogen pollution in Walloon [7]. Improving nitrogen use efficiency levels, which are relatively low by average OECD standards, has been recognised as one way of reducing nitrogen surpluses [20, 21, 33]. From 2003 some 40 active ***pesticide*** ingredients were prohibited out of a total 375 authorised ingredients in Flanders. This has help the region meet the 50% reduction target for its environmental pesticide risk indicator between 1990-2005 (for farm and non-farm pesticides) [14, 23].

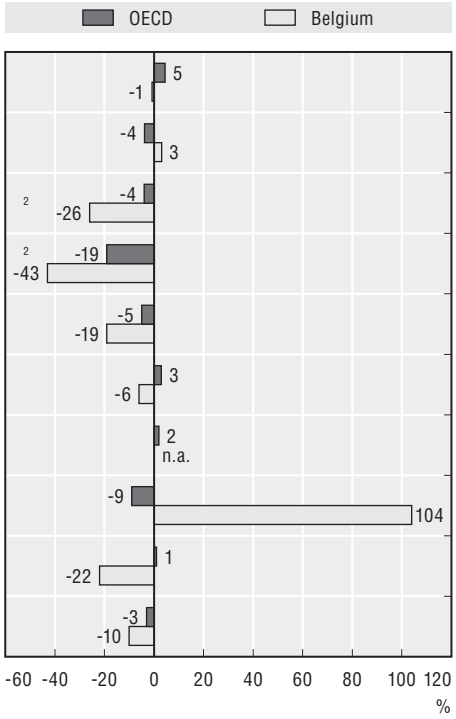
To meet the national ammonia emission ceiling target by 2010 agreed under the Gothenburg Protocol, emissions will need to decline by a further 8% from their 2001-03 average level. This compares to a reduction of 22% from 1990-92 to 2001-03. Some researchers consider it unlikely, however, that acidification will decrease sufficiently by 2010 to avoid damage to vulnerable ecosystems [27].

The farming sector has reduced its GHG emission levels, and this trend is projected to continue up to 2010 [34, 35], but the contribution from soil carbon sequestration could be modest [18]. While agricultural GHG emissions and on-farm energy consumption have decreased over the past 15 years, further reductions might be achieved if the fuel tax exemption for farmers were removed, which acts as a disincentive to lower energy use, improve energy efficiency and further reduce GHG emissions.

Concerning biodiversity risks of future adverse impacts from farming remain [27]. Implementation of meadow bird and floral protection schemes are progressing only slowly in Flanders [27], and were behind the targets set for 2006 [29].

Figure 3.3.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

Variable	Unit		Belgium	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	99	105
Agricultural land area	000 hectares	1990-92 to 2002-04	42	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	184	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	23	10
Agricultural pesticide use	tonnes	1990-92 to 2001-03	–1 283	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–55	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	n.a.	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	0.2	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–21	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–1 233	–30 462

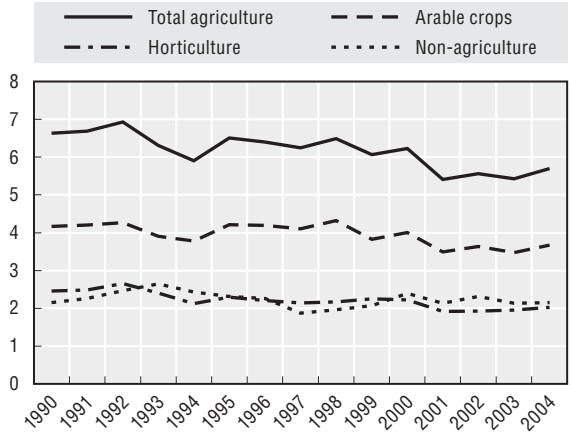
n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

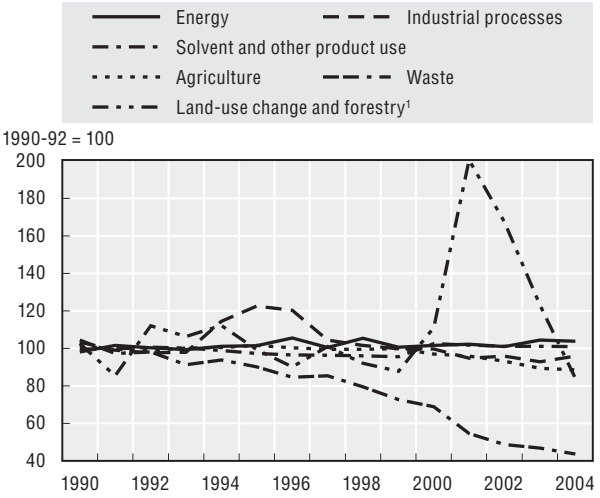
Figure 3.3.3. **Total pesticide use**

Thousand tonnes, active ingredients



Source: Crop Protection Department, Ghent University, Belgium.

Figure 3.3.4. **Greenhouse gas emissions and sinks**



1. Index shows the increase and decrease in GHG sinks.

Source: National inventory report under the UNFCCC, 2007.

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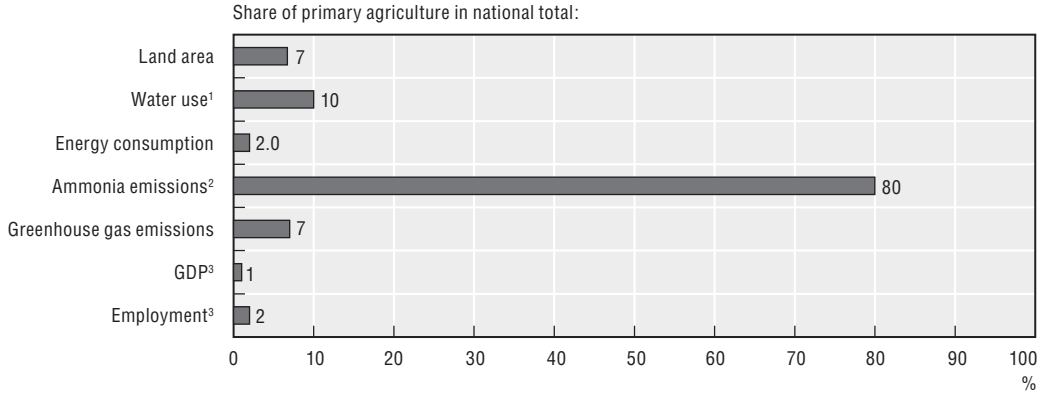
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3.4. CANADA

Figure 3.4.1. **National agri-environmental and economic profile, 2002-04: Canada**



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1. Data refer to the year 1996.
2. Data refer to the year 1995.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.4.1. Agricultural sector trends and policy context

Growth in agricultural production was more than double the OECD average between 1990-92 and 2002-04, owing in part to recent strong growth in production and sales in the pig and horticultural sectors (Figure 3.4.2). Farming's contribution to the economy accounts for around 2% of employment and 1% of GDP, while the whole agriculture and agri-food system accounts for approximately 13% of employment and 8% of GDP [1] (Figure 3.4.1). Canada is a major world exporter of cereals, oilseeds, animals and red meats (around 3% of world farm export value), with nearly 25% of production exported in 2004 [1, 2].

Agricultural production is intensifying and concentrated in fewer farms [1, 3]. Farm size and intensity varies across Canada depending on commodity specialisation, geography and land availability. The range of climates, soil types, resource availability, population distribution and competing land uses across the country allows some regions to implement more intensive management practices than others, including higher uses of inputs such as fertiliser, pesticides, energy and water (Figure 3.4.2), and higher densities of livestock. The result has been a greater rise in annual multifactor productivity growth for the agriculture sector (3%) than for industrial sectors (1.5%) over the period 1997 to 2003 [1]. The increase in intensity began in the 1940s, in part, due to economies of scale associated with a change to more capital-intensive technologies, with both farm and herd size increasing ever since [1]. This is reflected in that only one-third of farms report sales over CAD 100 000 (USD 76 000) but account for nearly 90% of farm production [1].

Agricultural support has declined. Support to farmers (as measured by the OECD Producer Support Estimate – PSE) fell from 36% to 22% of farm receipts between 1986-88 and 2002-04, compared to the performance of the OECD area where the average decreased from 37% to 30%. The share of output and input linked support also fell from 82% in 1986-88 to 57% of the PSE in 2002-04 [4]. The 2003-08 *Agricultural Policy Framework* (APF) provides Federal, Provincial and Territorial support to the farm sector through various programmes that fall under the headings of: business risk management; food safety and quality; environment; science and innovation; and renewal. Total agricultural expenditure was CAD 10 (USD 7) billion annually over 2002-04, or just under 1% of GDP [4].

There is growing emphasis on the environment in agricultural policy. Over the 1990s much of the focus of agricultural policy was on economic and production objectives, but environmental considerations became a key part of the APF [5]. Agriculture and environment are shared responsibilities between Federal, Provincial and Territorial governments. Most APF agri-environmental programmes are cost-shared between the Federal, Provincial and Territorial Governments, with CAD 700 (USD 490) million of funding over 5 years (2004-08) provided by the Federal Government [4, 6]. Programmes under the environment chapter of the APF provide producers with assistance to improve their environmental management of soil, water, land and biodiversity by cost-sharing activities such as technical assistance, extension, research and demonstration activities, although there are some exceptions [7, 8].

Several national environmental and taxation policies impact agriculture. The *Canadian Environmental Protection Act* addresses air pollution and toxic substances and involves the agriculture sector when developing risk management plans for listed substances. The Pest Management Regulatory Authority monitors and regulates pesticide products and their use under the *Pest Control Products Act*. Farmers are supported with an on-farm fuel tax exemption, equal to CAD 285 (USD 200) million annually during 2002-04 [9]. Some farm inputs (*e.g.* fertilisers, pesticides) are exempt from the Federal Goods and Service Tax [9]. Irrigation water charges have risen from CAD 11 to 31 (USD 7 to 22) per m^3 between the 1980s and 2000 [3]. *Integrated Water Resources Management* is being used to bring together Federal, Provincial and Municipal authorities in the planning and management of water policies [3, 10]. Biofuels are exempt from the Federal excise taxes on transport fuels [4].

Producers are also affected by commitments under several international environmental agreements. Under the *North America Free Trade Agreement* Canada, together with Mexico and the United States, is seeking greater harmonisation of pesticide regulations [2]. In eastern Canada producers are impacted by commitments made under the *Great Lakes Water Quality Agreement* with the US, co-ordinated through the International Joint Commission, which addresses concerns related to agricultural water pollution and water withdrawals for irrigation and other uses [3, 11]. A plan was initiated in 1997 to improve biodiversity conservation in agriculture as part of Canada's commitments under the *Convention on Biological Diversity*. [3]. Canada is a signatory to the *Kyoto Protocol* to address greenhouse gas emissions, the *Gothenburg Protocol* to reduce ammonia emissions (although emission targets have not yet been determined), and the *Montreal Protocol* to phase out ozone depleting substances, including methyl bromide.

3.4.2. The environmental performance of agriculture

The key environmental challenges concerning agriculture include soil, water and air quality. The growing agricultural demand for water and the impact of farming on biodiversity are also important issues. There are a number of environmental concerns between farming and urban communities [12, 13], notably odours from livestock operations, and the conversion of farmland to urban use [14]. Canada is the second largest country by area in the world, but climate, topography and the range of soil types limit the land suitable for agriculture to approximately 7% (2002-04) of the total land area [15]. Between 1990-92 and 2002-04 the total area of farmland decreased by over 2%, largely because the land suitable for agriculture is already being used for that purpose (Figure 3.4.2). Approximately 60% of farmland is cultivated, 30% pasture and 10% used for other purposes (*e.g.* woodlots). The increase in cropped land is primarily due to the reduction in the use of summerfallow in rotations. Summerfallow area decreased by more than half between 1981 and 2001. The more intensive use of cropland is a result of the adoption of management practices that allow for continuous cropping or extended crop rotations [2].

Overall soil quality – erosion, soil organic carbon, salinity – has improved, during the period 1991 to 2001. Improvements include: an increase in the share of cropland under vegetative cover for more than 300 days annually; a higher share of cropland in low erosion (water, wind and tillage soil erosion) and salinisation risk classes; and a net accumulation of soil organic carbon in cropland since 1996 (Figure 3.4.2) [2, 16, 17, 18]. These developments are a result of: increased adoption of reduced tillage or no-till practices, rising from around 30% in 1991 to 60% of cropland in 2001; reduced use of summerfallow; and expansion in the area of perennial vegetation which primarily involves the conversion of marginal cropland to forage production. There is still room for improvement, however. Approximately 4% of cropland considered to be at high risk for soil degradation (erosion and salinity) was still under cultivation in 2001. In 2006 about 28% of agricultural land in Canada remains under conventional tillage practices, with a higher share in the Atlantic Provinces and Québec, largely due to crop type and climate, and 30% of cropland is still considered to be in the low soil cover class (especially in Ontario and Saskatchewan) [2].

Water contamination from agricultural sources is a concern and risk of water contamination from agriculture has increased since 1981 [3, 19, 20, 21, 22, 23, 24, 25]. Agriculture is a key source of nitrogen and phosphorus in the environment, although risk of contamination tends to be localised [26]. The increase in nutrient surpluses is reflected in the rising trend in the Indicator of Risk of Water Contamination by Nitrogen (IROWC-N) [2]. For instance, the share of farmland in the high to very high risk category for IROWC-N rose from 11% in 1991 to 16% by 2001, and was about 50% in certain regions [2]. Some regions in Canada are at higher risk of poor water quality than others, owing to: surrounding land uses; population density; increased use of inputs, such as fertilisers; and climatic conditions of heavy annual or seasonal precipitation. Overall water quality in Canada is high but it is difficult to provide a national overview as there is no comprehensive water quality monitoring system [3, 21, 27]. About 10% of the total population draws water from private rural household wells, which routinely do not meet drinking water quality standards for bacteria and nitrates. In some Provinces environmental water standards are exceeded for pesticides and phosphorus [3, 21, 28, 29, 30] which also impacts livestock water supplies [28]. About 15% of rural wells exceed guidelines for nitrates in drinking water (45 mg/litre) [3]. Depending on the region, 20-40% of surveyed rural wells have occurrences of *coliform* bacteria in excess of drinking water guidelines [3, 28, 30].

The Great Lakes ecosystem is stressed by farm nutrients, pathogens, pesticides and soil sediments, both from Canadian and US sources. These pollutants threaten recreational opportunities and raises costs of treating drinking water and dredging harbours [31, 32]. There has been some improvement in certain areas of the Great Lakes, such as the attainment of guideline levels of phosphorus for all lakes (except Lake Erie), due to a reduction of P inputs from agricultural, municipal and industrial sources. There is evidence that Canadian agricultural nutrient inputs (especially phosphate) to the Great Lakes could be declining as a result of improved farm management practices [33, 34]. Nutrient surpluses are an issue in some key watersheds, such as Lake Winnipeg which is showing signs of eutrophication [41], although farming is not the only source of nutrient pollution [35].

Agricultural nutrient surpluses per hectare are among the lowest in the OECD, however, they show the highest per cent increase across the OECD (Figure 3.4.2). In absolute values, the N surplus was 35 kg N/ha, about half the OECD average of 74 kg N/ha (2002-04). Both nitrogen (N) and phosphorus (P) surpluses grew respectively by 85% and 123% between 1990-92 and 2002-04. Nutrient surpluses (in tonnes) have grown in response to: greater inorganic fertiliser use – N fertiliser use rose by 35% between 1990-92 and 2002-04 and P use rose by 11% over the same period; the rise in pulse crop area (*i.e.* greater biological nitrogen fixation) without a concurrent reduction in fertiliser use; and higher livestock numbers generating growing quantities of manure [2]. In 1990-92, an estimated 40% of farmland suffered from a nitrogen deficit, however, this problem was addressed and by 2001 no land showed a nitrogen deficit. There are large regional variations in nutrient balances, owing to differing climates and types of soil, farming types and crops types, and also varying topography across the agricultural regions of Canada [2, 37].

Nutrient efficiency has declined, but the ratio is close to the OECD average for nitrogen and above it for phosphorus (nutrient efficiency is defined as the ratio of nutrient inputs and outputs). While the share of farms with formal nutrient management plans is low at 15% in 2001, several management practices are being adopted to protect water quality such as: establishing riparian areas adjacent to surface water on 75% of farms; conducting regular (1-5 years) soil nutrient tests on approximately two-thirds of farms; avoiding livestock feeding less than 100m from surface water during winter (on over 90% of farms); and preventing direct access of grazing livestock to surface water (nearly 60% of farms). Manure storage and application are key elements of most nutrient management plans, but between 1995 and 2001 manure application methods changed little, manure storage capacity was relatively low compared to manure production and timing of applications was not always optimal [2]. Between 1995 and 2001, 15% of producers adopted the optimal beneficial management practices for application of manure, representing 18% of total manure produced [2]. In 2001 10-11% of pig, poultry and dairy farms and 6% of beef farms, reported making environmental investments to reduce the risk of contamination to the environment from their operations [37].

Pesticide sales in Canada doubled between 1990 and 2003 [1, 2]. The risks associated with higher pesticide use, however, may to some extent be offset by: the use of new lower dose products that allow for targeted application; the expansion of genetically modified crops that are more pest-resistant; and the growth in organic farming, which accounted for under 1% of farmland and farms by 2003 and 1-2% of food sales despite its rapid growth in the past decade [1, 38, 39]. The growth in pesticide use is linked to the expansion in crop production, reduction in the use of summerfallow and greater intensity of farming [1]. Pesticides are used on over 80% of cropland [2, 40]. Over 60% of farmers are certified as

pesticide applicators, however, more efforts are required to encourage the uptake of beneficial management practices, such as recalibrating the sprayer before changing products, and spraying products at optimal times [1].

Under 10% of arable and horticultural farms in 2001 reported making environmental investments for pesticide storage and to combat water pollution from pesticides [37]. Pesticide residues have been detected in water bodies, but there is no systematic monitoring of pesticides in the environment [2, 19, 30]. Only 0.1% of rural wells were found to exceed drinking water standards for pesticides, which suggests management practices are helping to reduce risks [3]. The share of fresh fruit and vegetables with detectable pesticide residues decreased over the period 1995 to 2002 [30]. Since 1994 more than 20 instances of fish kills (with up to 35 000 dead fish collected in each incident) were attributed to pesticides in Prince Edward Island, and in British Columbia birds of prey were lost following the use of granular pesticides [40].

Agricultural water use is increasing. Water resources are abundant nationally; however, water availability varies across different regions of the country [2, 3]. In 1996 agriculture's share of total water use was over 10%, having increased by 3% from 1991 (Figure 3.4.2). Most of the growth in water use is being driven by the expansion in the area irrigated, which rose by 20% from 1990-92 to 2001-03, with most irrigation occurring in Alberta (55%) and British Columbia (21%) [19]. About 30% of irrigators in 2001 were fully or partially using best management practices. Water for irrigation is largely drawn from surface water [41, 42]. A study of Alberta shows improvements in irrigation efficiency over the past 30 years, but there is room for further progress with over 20% of the irrigated area using the less efficient gravity irrigation practices [43]. Increased risk of drought is a growing problem for farming in some regions, and one of Canada's most costly types of natural disaster [10], even in some of the usually more humid areas, such as the Atlantic Provinces [3].

Trends in harmful air emissions from agriculture have shown mixed results. The 3% growth in ***ammonia emissions*** between 1990 and 1995 was largely due to an intensification of livestock operations (Figure 3.4.2). Farming accounted for 80% of anthropogenic ammonia emissions, of which over 80% were from livestock. As industrial sources of acidifying substances (*e.g.* sulphur dioxide) have declined, the rise in agricultural ammonia emissions has eroded the benefits from this reduction [26]. In 2003 gaseous ammonia was listed on Schedule 1 of the *Canadian Environmental Protection Act* for its potential risk to human health as a precursor to fine particulate matter. Research is ongoing to learn more about ammonia emissions levels, transport, deposition and interaction with other substances in the air, and the contribution of the agriculture sector to the emissions. Over 45% of the total land area is highly sensitive to acid rain, with ammonia emissions contributing to the acidification of terrestrial and aquatic ecosystems [27, 44].

Canada has agreed to phase out its use of methyl bromide by 2005 under the **Montreal Protocol.** By 2004 use was reduced by over 70% from 1991 levels. In 2005 a *Critical Use Exemption* (CUE) was agreed, that allows methyl bromide use of up to 37 tonnes ozone depleting potential, which under the terms of the *Protocol* allows farmers more time to find substitutes for this pesticide.

Net greenhouse gas (GHGs) emissions from agriculture increased by around 1% between 1991 and 2001. This reflects an increase in both nitrous oxide, due to increased crop production and fertiliser use, and methane emissions, from the higher intensity in livestock operations, offset by a large net increase in carbon sequestration by soils as a

result of land use changes and improved management practices (Figure 3.4.3) [2, 45, 46]. Changes in agricultural management practices which are being implemented across Canada to reduce emissions, are largely market driven through innovations in equipment, as well as changes in relative prices of crops and inputs [47]. The increase of gross agricultural GHG emissions over the period 1990-92 to 2002-04 (18%) was substantially above the OECD average (–3%) but lower than the rise of 23% for total Canadian GHG emissions (Figure 3.4.2). Agriculture's share in total GHGs was 7% in 2002-04. Canada's commitment under the *Kyoto Protocol* is to reduce total GHG emissions by 6% by 2008-12, but recent announcements by the Government of Canada indicate that it may not be possible to meet this target.

Direct on-farm energy consumption rose by 5% between 1990-92 and 2002-04, which contributed to GHG emissions (Figure 3.4.2). Farm energy efficiency (the ratio of energy inputs to outputs) declined by 3% over the period 1989-93 to 1997-01, mainly due to the rise in diesel fuel and fertiliser use, the largest input components [2]. The production and consumption of ***renewable energy*** from agricultural biomass is minor compared to national total energy consumption, although under the new federal policy on biofuels the target is to achieve a 5% average renewable fuel content in transport fuel by 2010. This should create opportunities for biofuel producers to increase their renewable energy capacity [48, 49, 50].

Overall pressure on agricultural biodiversity continues. For ***agricultural genetic resources***, Canada has *in situ* programmes and extensive *ex situ* collections of plant and animal genetic material, and efforts are underway to further expand this capacity [41, 51]. The number of major crop varieties and livestock breeds used in production has increased in diversity over the period 1990 to 2002. During this period the number of endangered livestock breeds rose from 47 to 51 (mainly cattle and sheep breeds), with only one breed under a conservation programme. This is in contrast to most other OECD countries where numbers of endangered breeds have declined as more livestock have come under conservation programmes, although two Canadian non-governmental organisations are involved in conserving rare livestock breeds [41].

There has been a substantial increase in the area under transgenic crops since the mid-1990s, accounting for 9% of the total agricultural land area in 2005, mainly canola with 70% of the sown crop genetically modified (GM) [35]. Canada is now the second major OECD producer, in terms of area, of transgenic crops after the United States.

The capacity of farmland to support wildlife showed a decline over the period 1991 to 2001. Over this 10 year period, 87% of Canada's farmland showed moderate to large decreases in habitat capacity compared to the 1981-2001, period when 30% of Canada's farmland showed a moderate to large decrease in habitat capacity (Figure 3.4.4). The agricultural intensification that has occurred in some areas of the country since 1981 is considered one of the drivers of the decrease in habitat capacity, such as the increase in cropland that occurred at the expense of more valuable habitats, for example wetlands, woodlots and natural pasture in Eastern Canada. Agricultural habitats, however, make a significant contribution to supporting many wild species by providing the necessary resources for breeding, feeding and cover [2].

Overall 24% of farms in 2001 were fully or partially using best management practices for wildlife conservation [41]. A number of regional studies suggest that the changing structure and fragmentation of agricultural habitats, and some farming practices, have raised concerns for the conservation of terrestrial and aquatic ecosystems, for example: the reduction in size and

loss of forest patches on farmland [52]; the fragmentation of native ecosystems [53, 54, 55]; the drainage of agricultural land and straightening of watercourses [55, 56, 57]; and run-off of excess nutrients and pesticides into surface water bodies.

The conversion of native ecosystems to farmland is considered to have been the main cause for the decline of most wild species, including threatened species [58]. The Canadian Wildlife Service grassland species breeding bird population index, decreased by almost 30% between 1990-92 to 2002-04, part of a longer term downward trend since the late 1960s, although from 2001 to 2004 there has been a small upward trend in the index of almost 10% [59]. Possible causes of the decline in grassland bird species include agricultural activities, urban growth into rural areas, and a decline in quality of wintering sites, among others. There is also evidence of recent increases in the Prairies breeding duck populations, although the longer term trend has been variable, for example declining in Southern Alberta, but expanding in Southern Saskatchewan [60].

3.4.3. Overall agri-environmental performance

Changes in farming practices and land use over the past decade have been successful in addressing environmental issues in some areas, but still need improvement in others. The adoption of soil management practices have resulted in improved soil quality, however the expansion and intensification of production over the past decade has increased environmental pressures in other areas [2, 61]. These include mainly water quality, especially in relation to manure management; growing competition for water resources; increase in ammonia and greenhouse gas emissions; and pressure on biodiversity. Given the size of Canada and its diversity of climate and soil types, there are wide regional differences in the environmental impacts of agriculture.

A comprehensive set of indicators to monitor the environmental performance of agriculture has been developed, within the context of *Canada's Agricultural Policy Framework* (APF) [2, 61]. Two agri-environmental indicator reports have been published to date (2000 and 2005), and a third is planned for 2008/09. Further development work is underway to strengthen the agri-environmental indicators in a number of areas, for example, soil biodiversity, particulate matter, and integrated pest management [2, 5]. A crucial challenge for indicator development and policy integration capacity are data limitations in key areas, such as pesticide use, agricultural water use, and a national monitoring network on water quality.

Canada is one of only a few OECD countries that does not regularly report the annual volume of pesticide use, although the Federal government stated in 1994 that it would establish a pesticide use database [40]. The lack of a national monitoring network on the quality of water (surface and groundwater) in rural areas has also been recognised as an impediment to effective policy analysis [33], while data related to agricultural water use are poor [42]. Efforts are being made, however, by the Federal government to collaborate with Provincial governments to fill these gaps, by conducting national surveys and establishing collaborative relationships with industry and academia. Agriculture and Agri-Food Canada is investigating the relationship between trends in critical habitat for wild species at risk and trends in agricultural land use.

Growing efforts by Federal and Provincial governments are tackling agri-environmental concerns. Under the environment pillar of the APF several programmes have been launched with the goal of reducing the sector's risk to the environment while remaining economically competitive. Programmes such as the *National Farm Stewardship Program*

provide technical support for producers to conduct environmental scans of their operations and develop *Environmental Farm Plans*. The Plans that identify actions to improve on-farm environmental performance, as well as providing cost-share support to implement these actions (*i.e.* fencing livestock out of water). There is still room for improvement to limit the impact of pesticides in the environment, however, work is ongoing to encourage producers to develop and adopt integrated pest management (IPM) systems which allow for continuous monitoring, adoption of alternative strategies for controlling pests, and targeted and efficient use of pesticides when required. The uptake of IPM practices is beginning to increase.

Within the APF the four-year CAD 60 (USD 45) million National Water Supply Expansion Program (2005) will address the growing risks of water shortages. The Program is making support available for on-farm water infrastructure, among other measures, and by providing a third of project costs [4]. The *Environmental Technology Assistance for Agriculture* programme evaluates innovative new technologies and production systems that are expected to contribute to improved on-farm economics and environmental performance, through nutrient management and the production of biofuels and renewable energy. Some of the key Provincial Government agri-environmental initiatives include: the implementation of a tax of CAD 1.2 (USD 0.8) per litre of pesticides in British Columbia; and Quebec's CAD 28 (USD 20) million *Prime-Vert Program* to control manure related pollution including a subsidy of 70-90% for the construction of manure storage facilities and restraints on manure spreading over winter [3, 5, 62].

The greenhouse Gas (GHG) Mitigation Program is an information and awareness programme, that encourages voluntary adoption of farm practices to reduce GHG emissions and increase carbon sinks. A comprehensive strategy to implement a 5% renewable fuels mandate for transport by 2010 is being established. The strategy plans to provide significant government incentives to support the expansion of the ethanol and biodiesel industry, and investment in research and development to encourage the growth of second generation biofuels, such as cellulosic ethanol.

A number of Provincial governments have in recent years introduced a range of measures to control water pollution from intensive livestock operations. These include, for example, the *Nutrient Management Act* in Ontario and the *Water Protection Plan* in Manitoba, which set targets for N and P levels in water bodies, and regulate some activities such as the timing of manure spreading to reduce risk of water contamination by agricultural sources [3, 19, 63]. Continued promotion of management practices that help reduce run-off of fertilisers and pesticides into the Great Lakes are planned as there are still improvements to be made [11]. Canada and the United States have also been working closely to develop an action plan to mitigate agricultural and industrial risks to the Great Lakes Basin under the *Great Lakes Regional Collaboration*, which aims to set goals to 2010 and 2015 to reduce agricultural pollutants into the Great Lakes, such as reducing livestock non-point source loading [31].

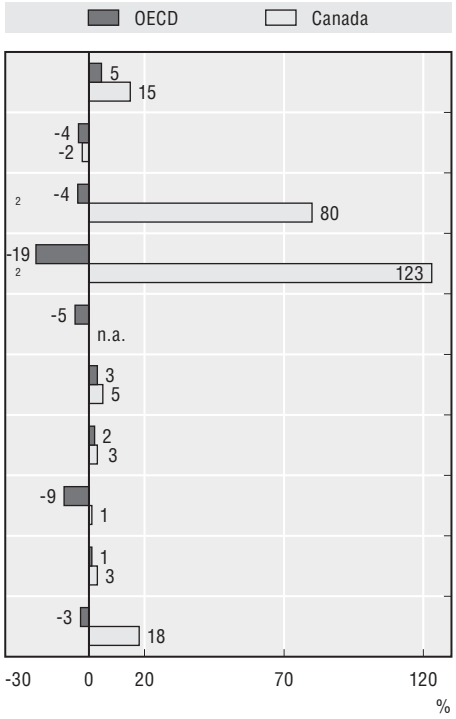
The agriculture sector is continuing efforts to reduce emissions of ammonia through the development and implementation of beneficial management practices that address manure management, storage and spreading and fertiliser application and storage. Research is ongoing to learn more about ammonia emission levels, transport, deposition and interaction with other substances in the air, as well as develop new beneficial management practices to reduce risk.

The projected expansion of agriculture to 2015 presents a considerable challenge to avoid an increase in environmental pressure [2, 64]. Changes in farming practices, especially the shift to reduced or no tillage, and land use changes, notably the reduction in summer fallow have yielded considerable environmental benefits, including: improved soil and water quality; lower energy use; reduced greenhouse gas emissions; and improvements for biodiversity. But these gains have partly been offset by the decreasing efficiency of nutrient and energy use. Rapidly growing nutrient surpluses could be offset with improvements to increase the uptake of best managements practices (BMPs), as only 15% of farms use BMPs to apply manure. Raising the efficiency of nutrient use would bring economic and environmental benefits. Subsidising on-farm fuel costs is a disincentive to improving energy use efficiency, reducing GHGs, and adopting conservation tillage (which requires less energy than conventional tillage) [65]. Only 6% of farms reported investment in environmental protection (*i.e.* manure storage, pesticide and fuel storage and waterway protection), averaging over CAD 19 200 (USD 12 400) or almost 4% of total farm investment in 2001 [37, 66].

A further challenge will be meeting Canada's international environmental commitments related to agriculture. The *International Joint Commission* has been requested to examine water diversions and removals from the Great Lakes, including for irrigation purposes, especially as water use conflicts and litigation have increased rapidly over the past decade [3]. Subsidised irrigation water and infrastructure do not facilitate the conservation of water resources and promotion of the efficient allocation of water between farming and other uses [3, 19]. While there has been success in lowering the use of *methyl bromide* since 1990, a further reduction will be required if Canada is to phase out its use as agreed under the *Montreal Protocol*. Given the increase in agricultural *ammonia* and gross *GHG emissions* it will also be a major challenge for Canada to meet its commitments to reduce emissions under the respective *Gothenburg* and *Kyoto Protocols*, although success has been achieved in increasing carbon sequestration in agricultural soils, helping to reduce net GHG emissions.

Figure 3.4.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

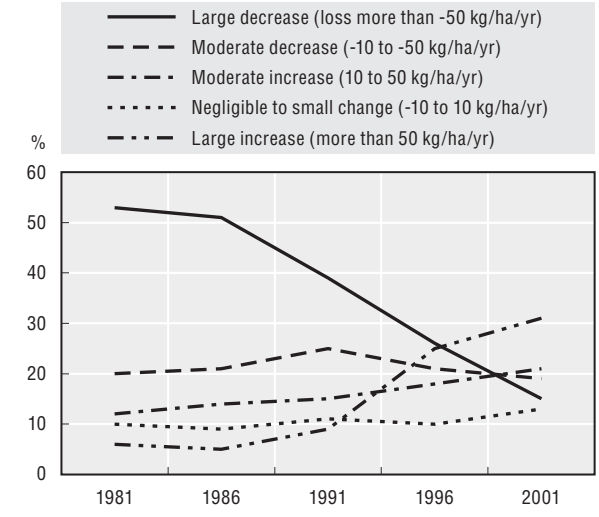
Variable	Unit		Canada	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	115	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–1 521	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	35	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	1	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	n.a.	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+184	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+113	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	3.6	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	+14	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	+8 043	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

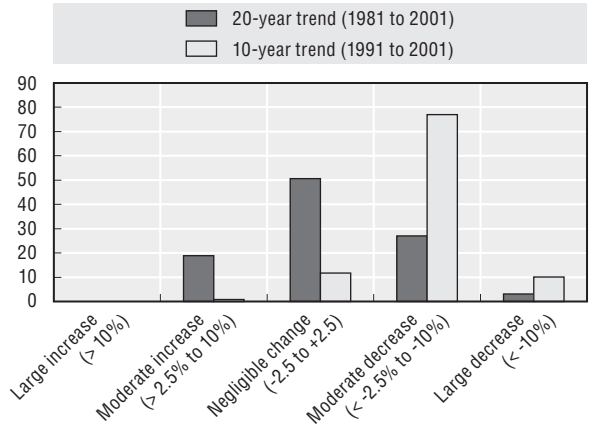
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.4.3. **Share of cropland in different soil organic carbon change classes**



Source: Lefebvre, A., W. Eilers and B. Chunn (eds.) (2005), *Environmental Sustainability of Canadian Agriculture*, AEI. Report Series, Report 2, Agriculture and Agri-Food Canada, Ottawa.

Figure 3.4.4. **Share of farmland in different wildlife habitat capacity[1] change classes**



1. "Habitat capacity" is the capacity of agricultural land to sustain populations of wild terrestrial vertebrates, *i.e.* birds, mammals, reptiles and amphibians.

Source: Lefebvre, A., W. Eilers and B. Chunn (eds.) (2005), *Environmental Sustainability of Canadian Agriculture*, AEI Report Series, Report 2, Agriculture and Agri-Food Canada, Ottawa.

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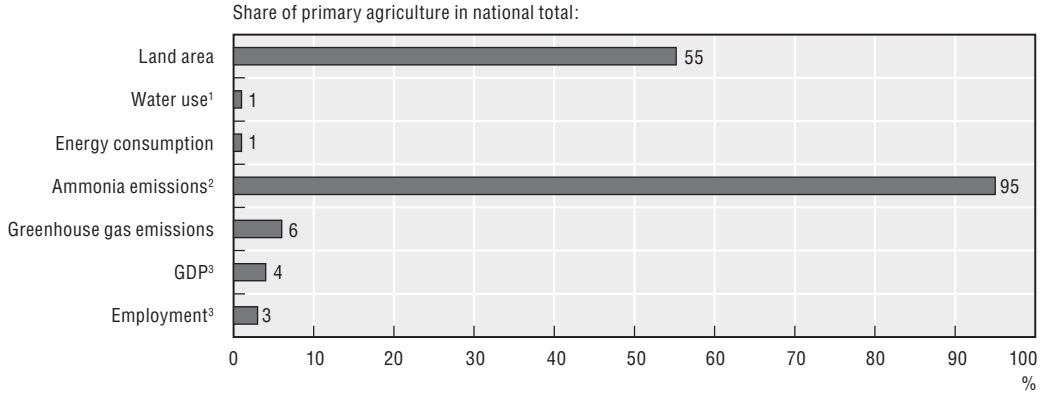
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3.5. CZECH REPUBLIC

Figure 3.5.1. **National agri-environmental and economic profile, 2002-04: Czech Republic**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2001.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.5.1. Agricultural sector trends and policy context

The long term contraction of the agricultural sector continued over the period 1990 to 2004 [1]. The share of agriculture in GDP declined steadily from 7% in 1990 to just over 4% by 2004, while over the same period farming's share in total employment fell from 10% to 3% [1, 2, 3, 4, 5] (Figure 3.5.1). These changes are reflected in the reduction of 10% in the volume of agricultural production (1993-95-2002-04), one of the largest decreases across OECD countries (Figure 3.5.2). While livestock numbers declined, continuing a longer term trend since 1990, over the more recent period from 2000 to 2005 arable crop production has risen slightly, especially for cereals, oilseeds and sugar beet [6].

Transition from a centrally planned to a market economy has impacted significantly on agriculture since the early 1990s. Major changes in political and social institutions and economic conditions, the division of Czechoslovakia in January 1993 into the Czech and Slovak Republics, and the shift from a centrally planned to a market economy, have all had implications for land use decisions. There have been extensive changes in farm ownership patterns, productivity and competitiveness [7, 8, 9, 10, 11, 12]. Overall the sharp fall in the volume of farm production during the early 1990s was induced by a major reduction in support (see below), a drop in farm investment, and rising farm debt levels. The use of purchased farm inputs (fertilisers, pesticides, energy and water) decreased sharply in the early 1990s but stabilised and even began to rise slightly from the late 1990s, although by 2005 still remained well below their peak of the late 1980s [6, 13]. While private family farms saw their share of the area farmed rise from under 1% in 1989 to around 27%

by 2002-04, farm production remains concentrated on large co-operative and corporate farms (privatised successors of former state and co-operative farms) with an average size of over 500 hectares (well above the EU average), and accounting for 72% of farmland [1, 5].

Farming is now supported under the Common Agricultural Policy (CAP), with support also provided through national expenditure within the CAP framework. Support to agriculture has fluctuated considerably over the past 20 years. Due to the implementation of economic reforms support declined from almost 70% of farm receipts in the mid-1980s to a low of 10% in 1997 (as measured by the OECD Producer Support Estimate – PSE), but then gradually rose to 27% by 2003, as policies were geared toward EU membership in 2004 [3, 4, 5]. The EU15 PSE was 34% in 2002-04 compared to the 31% OECD average [7, 14]. Nearly 70% of EU15 support to farmers was output and input linked in 2002-04, the forms of support that most encourage production [7]. Total annual budgetary support to Czech agriculture was nearly CZK 28 (EUR 0.88) billion in 2004, of which about 60% was nationally financed, the remainder coming from EU funding [7]. Agri-environmental measures in the Czech Republic accounted for about 5% of total budgetary support in 2004 [1].

Agri-environmental and environmental policy has had to address some key challenges. Firstly, policy had to respond to the environmental problems that are a part of the legacy of central planning; and secondly, policy changes have been required for EU accession and membership. In the early years of transition, agri-environmental policy was not a priority, while the government lacked resources to invest in environmental protection [3, 15]. Indirectly, however, through the removal of government support for purchased farm inputs (*e.g.* fertilisers, pesticides) and other production related support, the effect was to lower agricultural production intensity and pressure on the environment. Even so some agri-environmental policies were introduced over the 1990s, such as: the 1994 *Landscape Care Programme* (Údrzba Krajiny), which provided payments to permanent grassland in less-favoured areas (mountainous and hilly areas) of about CZK 2500 (USD 78) million annually in the late 1990s; specific production restrictions in National Parks and Protected Landscape Zones; area payments to promote organic farming; a tax per head on ruminant animals to reduce ammonia emissions; and an afforestation scheme over the period 1994-2001 which paid farmers about CZK 380 (USD 12) million in total for nearly 3 800 hectares of tree plantings on farmland (about 0.1% of total farmland at this time) [2, 3, 14].

EU accession and membership from 2004 has also brought policy changes. The EU provided pre-accession funds for agriculture up to 2006 (including for environmental purposes) through three programmes: *SAPARD*, the most important for agriculture in terms of funding the establishment of institutions and systems of policy implementation; *PHARE*, covering institutional building; and *ISPA*, to assist infrastructure development, including environmental protection [14, 15]. The EU accession period since 2004 has required the adoption of EU agri-environmental and environmental policies, and harmonisation of technical standards [7, 15]. Policies under the CAP are being phased in up to 2013, when CAP support will reach 100% of the EU15 level. The *Horizontal Rural Development Plan* (HRDP) provides the objectives and outlines the main agri-environmental schemes for 2004 and 2006, including schemes: to reduce soil degradation and water pollution; to protect biodiversity; and to promote environmentally beneficial farming practices. The estimated cost is CZK 10.05 (USD 0.42) billion of which 80% is EU funding [2, 4]. Payments for organic farming are continued under the HRDP, having risen from CZK 48 to 230 (USD 1.5 to 8.2) million between 1998 and 2003, with 6% of agricultural land under organic management [1, 16, 17, 18, 19]. To comply with the *EU Nitrate Directive*, the 2004 *Nitrate*

Action Programme established *Nitrate Vulnerable Zones* to regulate farms in terms of fertiliser and manure application and storage practices, and provide farm support of CZK 5 400 (USD 210) million to aid investment for the construction of manure storage facilities [4, 20].

Agriculture is affected by national environmental and taxation policies. The *State Environmental Policy 2004-10* seeks, among other objectives, to reduce non-point water pollution, including from agriculture [17, 21]. Under the *Act on the Protection of Agricultural Land Resources* (1992), a tax is charged for removal of land from agricultural production, with a lump sum for permanent withdrawal and an annual fee for temporary withdrawal. This scheme raised tax income of CZK 590 (USD 18) million in 2002 with 60% of the tax revenue going to the *State Environmental Fund* and 40% to the municipality for rural development and environmental protection [3, 13]. Farm fuel use is supported through a tax exemption. During 2005 this tax exemption was equivalent to about CZK 1 489 (USD 62) million of budget revenue forgone [22, 23]. Support is provided for investment in irrigation infrastructure (for orchards, vineyards and hops), amounting to CZK 23 (USD 1) million in 2006. While farmers are exempt from the surface water withdrawal charge, they pay a groundwater abstraction charge of CZK 3 (USD 0.13 cents) per m^3 for volumes in excess of 500 m^3 per month [4, 13, 20, 22].

International environmental agreements also have implications for agriculture, with respect to limiting emissions of: ammonia (*Gothenburg Protocol*), methyl bromide (*Montreal Protocol*) and greenhouse gases (*Kyoto Protocol*). Emissions of ammonia and methane were taxed at CZK 1 000 (USD 44) per tonne until 2002 after which the tax was removed [3, 24, 25]. The use of agricultural biomass as a feedstock for renewable energy production has been supported since the early 1990s through: income tax relief, interest subsidies and loan guarantees for installations using biomass for producing biofuels and biogas; feed-in tariffs for electricity production from biomass; and reduced value added tax (lowered from 23% to 5% since 1995) amounting to nearly CZK 500 (USD 18) million of budget revenue forgone annually between 2002 and 2004; and exemption from excise duties for biodiesel from 1995 (although the tax was reintroduced from 2000 [3, 4, 6, 24, 26]). As part of its commitments under the *Convention of Biological Diversity*, the *National Biodiversity Strategy*, along with a range of other measures, promotes the conservation and use of agricultural genetic resources through a *National Programme* as well as the protection of mountain biodiversity and agricultural landscapes [17, 21, 27, 28]. The Czech Republic has a number of bilateral and regional environmental co-operation agreements with neighbouring countries, notably concerning water resources and pollution through the *Agreements on International Commission for Protection of the Elbe, Danube and Odra* river basins. These have implications for controlling agricultural water pollution [4, 20].

3.5.2. Environmental performance of agriculture

Environmental concerns related to agriculture have changed dramatically over the past 20 years. With the reduction in farm production and input support, and shift to a market economy, farming moved from an intensive production orientated system to adoption of more extensive farming methods, linked particularly to the large decrease in use of purchased farm inputs. In the pre-transition period the primary agri-environmental problems were soil erosion, heavy pollution of some water bodies and poor uptake of environmentally beneficial farming practices [3]. Over the 1990s certain environmental problems persisted due to the legacy of decades of damaging farming practices, notably soil erosion and in some areas industrial pollution of farmed soils, especially from

acidification and heavy metals [3, 13, 21, 29, 30]. While the pressure on water quality and biodiversity has eased with more extensive farming practices, agricultural water pollution continues and land use change and cessation of farming has led to damage to biodiversity in some areas [13, 21, 25, 29, 31].

Soil erosion is a major and widespread environmental problem, partly because the share of arable land in total farmland is high at over 70% [13]. Data for the period 1999-2000 indicate that nearly 70% of farmland is affected by a medium to extreme risk of ***water erosion***, with nearly 30% subject to very high to extreme water erosion risk (greater than 6t/ha/year) [6, 13, 32]. Over three – quarters of farmland is at a tolerable and low risk of ***wind erosion***, but up to 40% of farmland in Moravia and 10% in Bohemia is potentially endangered by wind erosion [13]. Research suggests that off-site soil erosion from farmland has decreased significantly since the early 1990s due to land abandonment, conversion of arable land to pasture and forestry, and reduction in field size in some areas [30, 32, 33].

There has been a substantial increase in the area under soil conservation practices (for example conservation and zero tillage), with the share of arable land under these practices rising from 3% to nearly 30% between 1994 and 2000-03 [32]. But the share of farms adopting soil conservation practices in areas of high risk of erosion is less than 40%, while the share of arable land under vegetative cover over the year declined from 18% to 9% between 1989 and 2000-03. The overall share of farmland under vegetative cover over the year is relatively low (around 40%) compared to many other OECD countries (over 60%) [32, 33]. As a consequence off-farm soil sediment flows are causing water pollution through transporting nutrients into water bodies, while the deposit of silt in rivers and reservoirs is exacerbating the severity of floods [2, 25]. Between 30% and 50% of farmland is affected by ***soil compaction***, mostly caused by the movement of unsuitable farm machinery on wet soils [2]. There has been some improvement over the 1990s in the ***industrial air pollution of agricultural soils***, especially from acid rain and heavy metals, including the re-cultivation of previously contaminated soils [3, 13]. Very few soil samples by 2000-03 had above limit contents of hazardous elements, although cadmium in lighter soils remains a concern [13].

Overall there has been a long term reduction of water pollution from agricultural activities, between 1990 and 2004 [20]. This has been closely associated with the sharp decrease in nutrient surpluses, especially as a result of lower fertiliser use and livestock numbers, and reduced pesticide use over the 1990s [3]. But in the period from the late 1990s there has been a small rise in nitrogen surpluses (but not phosphorus) and pesticide use, with the pollution of surface water and groundwater in some intensively farmed areas remaining stable and in certain cases slightly rising [20].

There have been substantial reductions in agricultural nutrient surpluses (Figure 3.5.2). The trends in the intensity of nutrient surpluses per hectare of total farmland, both of nitrogen (N) and phosphorus (P), over the period from the late 1980s to 2004, fluctuated considerably [33, 34]. In the late 1980s nitrogen surpluses (expressed as N/kg/ha) were at a level comparable to those of the EU15 average (but above the EU levels for phosphorus), although by the early 1990s nitrogen surpluses were halved, and P surpluses decreased from around 30 kgP/ha of farmland to about 2 kgP/ha by the mid/late 1990s. From the late 1990s there has been a slow increase in N surpluses (stable for P surpluses), although they were still well below the levels of the late 1980s. The reduction in support to fertilisers and crop and livestock products during the transition period largely explains the decrease

in nutrient surpluses [4]. This is highlighted by the fluctuations in the use of inorganic N fertilisers which fell from (figures in brackets are for P fertilisers) around 420 000 (300 000) tonnes in the late 1980s down to 200 000 (under 50 000) tonnes in the early 1990s, rising to nearly 300 000 (over 50 000) tonnes by 2002-04, but still well below the level of the late 1980s.

Agricultural pollution of water bodies from nitrates declined over the 1990s but remains significant [13, 17] (Figure 3.5.3). This is illustrated by the *Nitrate Vulnerable Zones* (designated under the *EU Nitrates Directive*) which accounted for around 46% of farmland in 2004 [2, 4, 20]. The high rate of soil erosion in some areas is a key source of ***nitrate water pollution*** from agriculture, despite reductions in nitrogen surpluses. Moreover, all farms have been under a nutrient management plan since the early 1990s, with soil nutrient testing conducted every 6 years since 1993 [32, 35]. With the greater reduction in point sources of nitrate pollution of water (*e.g.* from industry) the importance of diffuse agricultural pollution is growing, with rising levels of nitrogen surpluses since the late 1990s further raising pressure on water quality (Figure 3.5.3) [2, 13]. The pollution of water bodies from agricultural ***phosphorus*** is much less significant, mainly because of the reduction in P surpluses have been greater than for nitrogen over the 1990s [2]. In the late 1990s farming accounted for about 40% of nitrates and 30% of phosphorus in surface water [4, 25]. A number of reservoirs and fishponds suffer eutrophication from agricultural nutrient run-off, erosion and deposition from the air [4, 13, 17, 36]. Around 7% of groundwater monitoring points exceeded EU standards for nitrates in drinking water in 2000 [29].

The decrease in pesticide use was among the highest across OECD countries from 1990-92 to 2001-03 (Figure 3.5.2). Its use declined from around 9 000 tonnes (of active ingredients) in the late 1980s to about 3 700 tonnes by the mid-1990s, then rose to 4 300 tonnes by 2001-03 [4, 6, 13]. The reduction in support to pesticides and crops during the transition period explains much of the decrease in pesticide use, but also to some extent the expansion in organic farming and adoption of integrated pest management (IPM). Organic farming grew rapidly over the 1990s and accounted for over 6% of farmland in 2004, compared to under 1% in the early 1990s (among the highest share across OECD countries). Permanent grassland accounts for about 90% of land under organic management [1]. Although the area under IPM more than doubled between 1990 and 2003, it accounted for little more than 1% of the total arable and permanent crop area in 2003 [32]. The decline in pesticide use over the 1990s lowered the pressure on water quality, but rising use since the late 1990s has led to increased concentrations of pesticides in water [20]. Monitoring of pesticides in water is limited, but research has shown that only 1.5% of groundwater monitoring sites in 2003 reported Atrazine above drinking water quality standards [4, 20]. Despite the ban on the use of the DDT pesticide and its metabolites, in certain places concentration levels in soils from 2000 to 2003 were above permissible levels [13, 37].

As agriculture is largely rain-fed, use of irrigation is limited, accounting for 1% of the total farmland area in 2001-03, and mainly for horticultural crops. Farming's share in national water use was 1% in 2005 [20], while over the period 1990 to 2003 agricultural water use declined by over 80%, largely because the area irrigated was more than halved over this period [32]. There has been some improvement in the use of irrigation water application technology, with the share of the area irrigated under drip emitters rising from 3% to 18% between 1994 and 2003 [32].

The reduction in air pollution linked to agriculture, has been among the largest decrease across OECD countries over the past 15 years. Total ***ammonia emissions*** fell by 44% between 1990-92 and 2001, with agriculture accounting for 95% of these emissions in 2001 (Figure 3.5.2) [13]. The drop in emission levels has been mainly due to the reduction in livestock numbers and nitrogen fertiliser use, while a tax has also been applied to ammonia emissions. With total ammonia emissions falling to 77 000 tonnes by 2001, the Czech Republic has already achieved its 2010 emission ceiling target of 101 000 tonnes required under the *Gothenburg Protocol*. Meeting the EU emission ceiling of 80 000 tonnes for 2010 will be more challenging, as projections suggest a small expansion in agricultural production up to 2010 [4]. For ***methyl bromide*** use (an ozone depleting substance) the Czech Republic is one of only a few OECD countries to have eliminated its use (by 2001) ahead of the complete phase-out agreed under the *Montreal Protocol* for 2005.

Agricultural greenhouse gas (GHG) emissions decreased by over 40% from 1990-92 to 2002-04 (Figure 3.5.2). This compares to an overall reduction across the economy of 18%, and a commitment under the *Kyoto Protocol* to reduce total emissions by 8% over 2008-12 compared to 1990 levels. Agriculture's share of total GHGs was 6% by 2002-04 [38]. Much of the decrease in agricultural GHGs was due to lower livestock numbers (reducing methane emissions) and reduced fertiliser use (lowering nitrous oxide emissions) [39]. Projections suggest that agricultural GHG emissions will steadily rise in the period from 2003-05 to 2020, as the farming sector expands following entry into the EU. Even so, agricultural GHG emissions are projected to be more than 60% below their level of the early 1990s by 2020 [39].

Agriculture has contributed to lowering GHG emissions by reducing on-farm energy consumption, but also by expanding renewable energy production and carbon sequestration in agricultural soils. Direct on-farm energy consumption fell by over 80% between 1990-92 and 2002-04 (compared to a reduction of 16% for total national energy consumption), the largest reduction across OECD countries (Figure 3.5.2). This is mainly because of the decrease in farm and energy support leading to lower production and higher energy prices. Farming accounted for only 1% of total energy consumption in 2002-04 [4]. Since the late 1990s on-farm energy consumption has stabilised, in part because of an increase in farm machinery use.

Renewable energy production from agricultural and other biomass feedstocks is expanding, but remains under 2% of total primary energy supply [40]. The main agricultural source for renewable energy is methyl-ester produced from rapeseed oil, which increased from 12 000 to 67 000 tonnes between 1995 and 2000 [26, 40, 41]. Methyl-ester production provided GHG emission savings of around 120 000 tonnes (CO_2 equivalent) annually between 2000 and 2005, but this is projected to decline to 90 000 annually by 2020 [39]. The use of agricultural biomass feedstocks for power and heat generation has been more limited compared to biofuels, however, there is considerable capacity to increase the use of agricultural biomass for renewable energy production [24, 26, 40, 41].

Carbon sequestration associated with agriculture has been increasing since the early 1990s, contributing to the reduction in GHG emissions [42]. The rise in carbon sequestration has been largely due to the conversion of cropland to pasture, and to a lesser extent the reduction in farmland converted mainly to forestry [13, 38, 39]. Over the period 1990 to 2003 the area of agricultural land declined by less than 1%, but the area of pasture grew by 13% in contrast to a 4% decrease in the arable and permanent crop area [38]. Projections suggest that from 2005 to 2020 these trends will continue, although at

a slower rate than during the 1990s [39]. It is also likely that the organic carbon content of agricultural soils rose slightly between 1992 and 2002, despite the drop in organic manure application due to lower livestock numbers [33].

Evaluating the effects of agriculture on biodiversity over the past 20 years is complex. This is because of the inheritance from the previous centrally planned economy which led to widespread damage to biodiversity, such as the removal of small habitats (*e.g.* woodlands), land drainage (*e.g.* loss of wet meadows), and farming on marginal soils [2, 3, 25, 29, 31]. Over the 1990s, the pressure on biodiversity from farming activities diminished, especially with the reduction in fertiliser and pesticide use and conversion of cropland to pasture, leading to the revival of some wildlife [29]. But while the overall farming system has become more extensive, in certain areas the abandonment of some semi-natural farmed habitats (*e.g.* grassland) has emerged as a threat to biodiversity [3, 13, 25, 31].

There are active* in situ *and* ex situ *programmes for agricultural genetic resource conservation [17, 27]. ***Crop varieties*** used in production have increased in diversity over the period 1990 to 2002 [32]. Crop genetic resources are mainly conserved *ex situ* in national gene banks and research centres, with over 52 000 accessions of all the major crops, horticultural plants, and grasses [43]. There is also some regular *in situ* monitoring of crop varieties, especially the propagation of horticultural varieties [17, 27, 43]. ***Livestock breeds*** used in marketed production have increased in number over the period 1990 to 2002, with a national programme since 1995 covering *in situ* conservation of livestock breeds and an *ex situ* gene bank established in 2000 [32, 44]. There is little information on the state or conservation of endangered crop varieties and livestock breeds, but concerns have been raised as to the need to conserve endangered varieties and breeds in risk of extinction, notably the Czech red cattle, the Valaska sheep and the Staroklandrubske horse [2, 25, 27].

Wildlife conservation is threatened, in particular, by the change in management and use of semi-natural grassland [2]. While estimates vary, semi-natural grassland accounts for between 10% and14% of agricultural land and 40%-60% of total permanent grassland and pasture [2, 4, 27]. The two key threats to semi-natural grasslands, which are usually associated with a rich and abundant wildlife that coexists with livestock at low stocking densities, are their switch to more intensive forms of management (*i.e.* higher stocking rates); or in some marginal mountain areas their abandonment where it may be too costly to convert them to cropland or forestry [25, 27, 31]. In this context, the ***White Carpathians***, a mountainous region in the east of the Czech Republic, is of significance as it has been recognised as a UNESCO Biosphere Reserve since 1996 with over half the region under pastoral semi-natural grassland [28, 31, 45, 46, 47]. These grasslands are considered to be among the most plant species rich in Europe with many protected species. But their continued existence is coming under a variety of threats, especially the increase in the area under fallow (5% by the late 1990s) and the reduction in livestock over the 1990s leading to the abandonment of some areas, or in others under-grazing below a level necessary to maintain the species richness of the grasslands [28, 31, 45].

Overall the impact of agriculture on wildlife has been mixed, despite the trend towards a more extensive agricultural system over the past 15 years. While the national index of bird population trends was almost stable over the period 1990 to 2003, farmland bird populations have sharply declined over the period from the mid-1990s to 2003, after previously rising from the mid-1980s. This trend is of concern as agriculture is estimated to have posed a threat, in the late 1990s, to around 55% of important bird habitats through

changes in management practices and land use [48]. Some farmland bird species are seriously threatened, such as the Common Partridge (*Perdix perdix*) and Corncrake (*Crex crex*) (Figure 3.5.4). Some game species have recovered in numbers since the mid-1990s such as the Pheasant (*Phasianus colchicus*), while others declined such as the Brown Hare (*Lepus europaeus*) [2, 4, 13, 17, 25].

3.5.3. Overall agri-environmental performance

Overall agricultural pressure on the environment has declined since 1990. The transition to a market economy has resulted in a more extensive farming system, leading to a decrease in the use of purchased farm inputs (fertilisers, pesticides, energy and water) and water and air pollution. With the small rise in farm input use since the late 1990s, water pollution in some intensively farmed areas has risen slightly [20]. Even so, by 2005 farm input use remained below its peak of the late 1980s. Soil erosion is a major and widespread problem, partly because the share of arable land in total farmland is over 70% [13]. With respect to biodiversity there are concerns over damage to semi-natural grasslands and the decline in farmland bird populations since the mid-1990s [2, 13, 17].

Improvements are being made to agri-environmental monitoring, to provide the information required to effectively monitor and evaluate agri-environmental performance and policies [25]. In some areas monitoring is well developed and established over a long period, notably soil, ammonia and greenhouse gas emission monitoring [25, 38, 39]. Time series data on agricultural water pollution is lacking, but a monitoring system is under development [4, 20, 21, 25]. Also projects financed under PHARE, for example, are seeking to improve the monitoring and evaluation system [2]. An important data gap is the monitoring of biodiversity, but this is now a priority area for the government [27]. As agri-environmental schemes are expanded, particularly with focus on agri-biodiversity conservation, this information will be important to help evaluate the effectiveness of these schemes.

Agri-environmental policies have been strengthened in the period since EU membership, but it is too early to see their effect on environmental outcomes. Particular emphasis has been given to promote organic farming through area payments, and under the 2004 *Action Plan for Organic Farming* the target is to expand organic farming to a 10% share of farmland by 2010 from the 6% share in 2004 [1, 16, 19, 21]. A high priority has also been given to renewable energy production. The goal of the Czech *Energy Policy* is to increase the share of renewable energy in total primary energy supply to 3-6% by 2010 and 4-8% by 2020, of which biomass agricultural and forestry biomass is expected to contribute a major share [40]. A combination of support: tax incentives, interest subsidies and loan guarantees, is being provided to expand agricultural biomass output as a feedstock for bioenergy production. The use of agricultural biomass feedstocks for power and heat generation has been more limited compared to biofuels, but there is considerable capacity to increase the use of agricultural biomass for renewable energy production [24, 26, 40].

Agricultural pressure on the environment has been much reduced but problems persist. With almost 50% of farmland exposed to the threat of ***soil erosion*** from water, soil conservation measures are currently inadequate to address the problem, with continuing off-site damage, including the transportation of nutrients and pesticides into water bodies, and the build-up of silt aggravating the severity of flooding [13, 21, 25, 35]. The conversion of some arable land to grassland in areas at high risk of erosion would bring benefits for soil and water protection [2]. While the uptake of soil conservation practices has risen, the share of farms adopting conservation practices in areas of high erosion risk is less

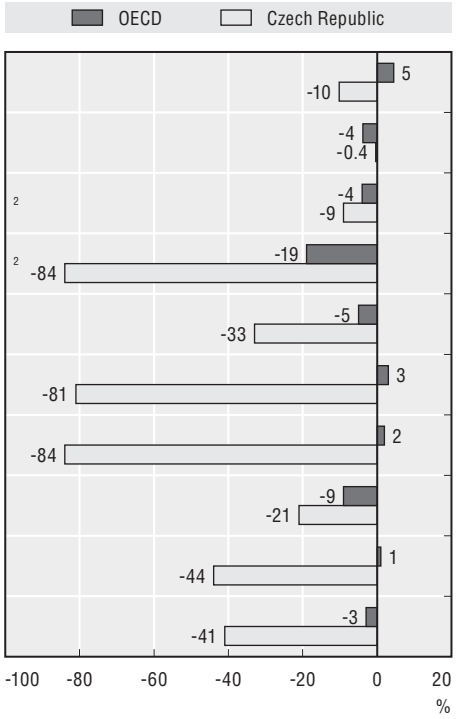
than 40%, and the share of arable land under vegetative cover over the year has been declining [32, 33]. ***Tax exemptions*** on fossil fuel used by farmers provide a disincentive to improve energy efficiency and help further reduce greenhouse gas emissions, although agriculture has reduced GHG emissions, energy use and increased renewable energy production. Moreover, support for irrigation infrastructure and exemption from surface water withdrawal charges reduces incentives to conserve water resources, but farmers do pay a groundwater abstraction charge [4, 13, 20, 22].

The pressure on biodiversity has eased as the intensity of farming has decreased. But there are concerns with the decline in farmland bird populations since the mid-1990s and threats to semi-natural grasslands [13, 21]. The key threats to semi-natural grasslands, which are associated with a rich and abundant wildlife in coexistence with low intensity pastoral systems, include: the switch to more intensive forms of management (*i.e.* higher stocking rates) in some regions; the increase in the area under fallow; and the reduction in livestock numbers leading to abandonment or under grazing in certain areas below a level sufficient to maintain the species richness of the grasslands [28, 31, 45]. It is possible, however, that wildlife has benefited from the conversion of cropland to grassland, as well as the effects of the lowering of agricultural water and air pollution on ecosystems, although there are few studies that have examined these changes.

The projected gradual expansion of agricultural production to 2020 could increase environmental pressure [39]. Under the recent changes of CAP reforms and together with EU enlargement, studies suggest this could lead to higher wheat and coarse grains production (but also to a reduction in the area under these crops) and contraction in livestock output, except sheep up to 2020 [39, 49]. As a result this may result in an overall rise in farm incomes and the concentration of production on fewer farms [7]. While these trends indicate a further increase in the intensity of production overall, the farming system is likely to remain at a significantly lower level of intensity up to 2020 compared to the 1980s, especially in terms of the use of purchased farm inputs, including fertilisers, pesticides, energy and water. Moreover, the total area farmed is projected to continue its long term decline due to the decrease in arable land, even though the area under permanent grasslands is likely to rise [39].

Figure 3.5.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

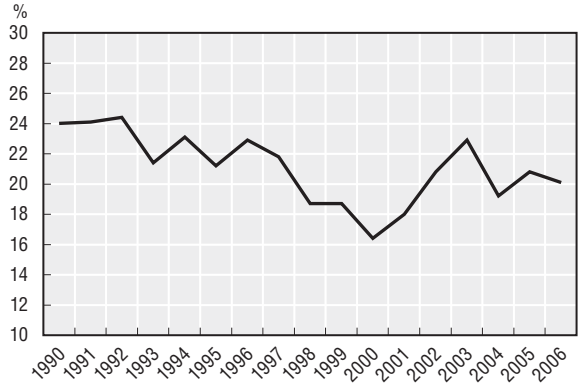
Variable	Unit		Czech Republic	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	90	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–16	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	70	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	2	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–2 237	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–1 064	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–78	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	0.6	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–58	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–5 658	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

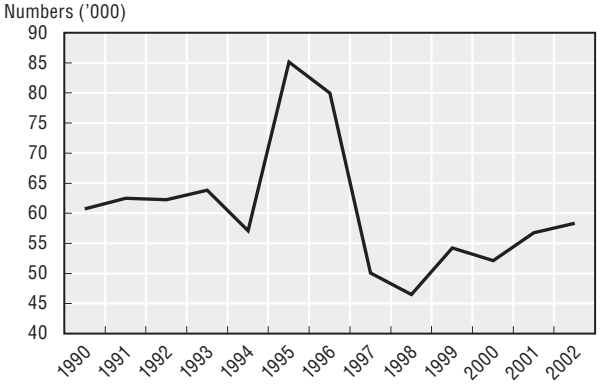
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.5.3. **Share of samples above Czech drinking water standards for nitrates in surface water**



Source: Annual reports on agriculture in the Czech Republic (issues from years 1995-2006), Ministry of Agriculture, Prague.

Figure 3.5.4. **Monitored numbers of partridge population**



Source: Ministry of Agriculture, Hunter association, *www.mze.cz*.

StatLink http://dx.doi.org/10.1787/300031561031

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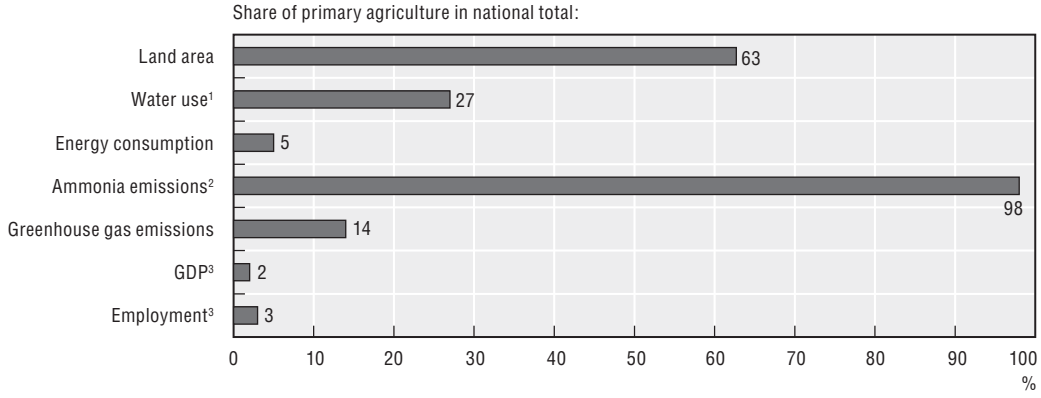
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3.6. DENMARK

Figure 3.6.1. **National agri-environmental and economic profile, 2002-04: Denmark**



StatLink http://dx.doi.org/10.1787/300053550738

1. Data refer to the period 2001-03.
2. Data refer to the year 2001.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.6.1. Agricultural sector trends and policy context

The role of primary agriculture in the economy is small and declining, accounting for 2% of GDP and 3% of employment in 2004. About two-thirds of farm production is exported, of which over 60% goes to EU countries with agricultural commodities accounting for 11% of the total value of exports in 2004 [1, 2] (Figure 3.6.1). Over the period 1990-92 to 2002-04 the intensity of farming has diminished with the area farmed declining by nearly 5% and even larger reductions in purchased farm input use: inorganic nitrogen (–47%) and phosphorus (–61%) fertilisers; pesticides (–37%, 1990-92 to 2001-03); and on-farm direct energy consumption (–24%) (Figure 3.6.2).

Overall the volume of agricultural production rose over the period 1990-92 to 2002-04, reflecting a 16% rise in livestock output, especially milk and pigmeat, which more than offset a reduction in crop production. The number of farms is steadily falling, with production concentrated on fewer but larger farms, with about 42% of farmers engaged full time [1]. Arable production is mainly located in the eastern part of the country, with cattle and pig breeding largely concentrated in north and west Jutland.

Farming is mainly supported under the Common Agricultural Policy (CAP) with support also provided through national expenditure within the CAP framework. Support to EU farmers has on average declined from 41% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate) compared to the 31% OECD average [3]. Nearly 70% of EU support to farmers is still output and input linked (compared to over 90% in the mid-1980s), which are the forms of support that most encourage production intensity. Total national

agricultural budgetary expenditure was DKK 2 450 (USD 408) million in 2004, of which 14% was funded by the EU, with 19% (DKK 466-USD 78 million) of the total used for agri-environmental programmes.

The main focus of agri-environmental policies is to reduce water pollution, but also protect water resources, biodiversity and landscapes. The third *Action Plan for the Aquatic Environment* (APAE III) (2005-15), building on the first and second Plan of 1987 and 1998 (a 1985 plan was a precursor to the APAEs, focusing on point source pollution from farms as well as storage of manure), aims to reduce farm nitrogen leaching by a further 13% and phosphorus surplus by 50% in 2015 compared to 2003 levels [4]. The Plan involves Government expenditure between 2005 and 2009 of DKK 863 (USD 144) million, with a further DKK 68 (USD 11) million provided by farmers [5, 6]. The APAEs have been central in implementing the EU *Nitrates Directive*. Previous APAE's have included: *mandatory standards* for animal housing, storage capacity and effluent containment; and *regulations* for the level and timing of manure application including the requirement that 65% of farmland must be under green cover during autumn and winter, and that farmers develop annual crop rotation plans and nutrient budgets. APAE III includes: expansion of catch crops and buffer strips along lakes and streams; a *tax* on phosphorus (see below); and *payments* for reestablishing former wetlands and afforesting farmland, which are intended to help reduce nutrient leaching and also provide other benefits such as carbon sequestration, biodiversity and landscape.

The objective of the Pesticide Action Plan (PAP) (2004-09) is to reduce the frequency of pesticide treatments to 1.7 applications per harvest year by 2009, compared to the target of 2.0 under the first PAP (2000-02) by 2002 [7]. The Plan provides annual payments of DKK 240 (USD 40) million to farmers not using pesticides, and DKK 144 (USD 24) million over 2004-09 covers technical assistance, decision support systems, training and approval procedures, while a pesticide tax is also applied (see below). The *Action Plan to Reduce Ammonia Volatilisation from Agriculture* (1998) requires compulsory coverage of manure stores, a ban on spreading liquid manure, and limits on manure application timing, while the APAE payments for buffer zones aim to cut ammonia emissions at specific locations by relocating livestock outside the zones [8]. In addition reduced ammonia volatilisation is one of the main criteria in the environmental approval system for farms which was implemented from January 2007. In 2009, the reduction has to be 25% compared to a reference level for stable and storage systems in 2005/06.

Cultivation of genetically modified (GM) crops was authorised in 2004, with GM crop measures funded at DKK 100 (USD 17) per annum for GM crops [3]. Up to the end of 2007 no GM crops have been commercially grown in Denmark. To ensure the possibility for GM and non-GM growers to co-exist, GM farmers must comply with a set of rules including: keeping a distance between fields of GM and non-GM crops; informing neighbouring farms about GM crop cultivation; and compensation for any loss of income for non-GM farmers caused by the spread of GM crops.

The Action Plan for Organic Production (1995) provides payments of about DKK 380 (USD 63) million annually from 2005 or DKK 930 (USD 155) per hectare to promote organic farming [6]. Organic farming is also a major focus point for the *Rural Development Programme* 2007-13. The Programme provides for a continued support for organic farming of DKK 750-3 750 (USD 125-625) per hectare and support for conversion costs when changing from conventional farming of DKK 2 400 (USD 400) per hectare, and support for

organic quality branding of DKK 27 (USD 4.5) million. Under both the Ministry of Food, Agriculture and Fisheries and the Ministry of the Environment, technology is seen as a major contributor to the reduction of farm pollution. It is integrated into all major polices and the Ministry of Environment has made an overall *Technology Plan*.

Agriculture is also affected by national environmental and taxation policies and international environmental agreements. The EU *Nitrate Directive* provides the main framework behind the APAE II, while the EU *Water Framework Directive* sets new environmental standards and shifts the focus from a national to a more local level to address pollution. *The Nature Protection and the Forest Acts* have been revised to enhance provisions protecting *Natura 2000* areas, designated under the *European Union Birds* and *Habitats Directives*, with provisions for regulation of farming activities that might affect the designated areas [3]. Under the *Water Supply and Watercourse Acts* farmers, since 1992, must provide a 2 metre buffer strip along all natural watercourses. As a part of ***national environmental taxation***, taxes are applied to the retail price of pesticides varying from 54% (insecticides) to 33% (fungicides, herbicides) and 3% (other pesticides). The revenue raised from the pesticide tax rose from about DKK 15 (USD 2.4) million when first introduced in 1998 to DKK 411 (USD 69) million in 2005, with over 80% of the tax revenue provided to farming organisations to improve pest management and the rest covering PAP costs. A tax of DKK 4 (USD 0.7) per kg of mineral phosphate added to livestock feed was introduced in 2005. Farmers are entitled to reimbursement of energy taxes on fuel and electricity and the carbon dioxide (climate change) tax, but the tax revenue forgone as a result of these exemptions is not known [9]. Payments and incentives were provided to encourage expansion of renewable energy production from agriculture over the 1990s, notably biogas through the *Biogas Action Programme* but the Programme ended in 2002 [10]. ***International environmental agreements*** important to agriculture include: those seeking to curb nutrient emissions into the Baltic Sea (*HELCOM Convention*) and the North Sea and Atlantic (*OSPAR Convention*); the *Gothenburg Protocol* concerning ammonia emissions; greenhouse gases (*Kyoto Protocol*); and commitments under the *Convention of Biological Diversity*.

3.6.2. Environmental performance of agriculture

The main agri-environmental issues are water pollution and biodiversity conservation. Agriculture's pollution of soils, water and air is mainly attributed to intensive livestock production, especially pigs and dairy cows, and the utilisation of inorganic fertilisers and pesticides. Soil erosion, especially as it relates to transporting pollutants to water bodies, emissions of ammonia and greenhouse gases, and conservation of cultural features in farmed landscapes are environmental issues of less importance.

On-farm problems from soil erosion are rare, but the off-farm impacts are a concern as an important process transporting pollutants to water bodies. Because of the low relief over most of the country soil water erosion rates are within tolerable levels (*i.e.* below 3 tonnes/hectare/year), although values of around 25 tonnes/hectare/year have been recorded [11]. But the greater production of winter cereals to help reduce nitrate leaching, under the APAE has had the unwanted effect of increasing erosion rates. The water erosion process, however, is a concern in terms of transporting pollutants into water bodies, especially phosphorus [11]. Wind erosion was a serious issue in western regions, but by establishing windbreaks the problem has been largely removed, with the number of plantings growing rapidly over the 1990s, mainly linked to the increase in payments for planting windbreaks [11].

Water consumption for irrigation has been declining, with agriculture accounting for around 17% of total groundwater abstractions by 2002-03 (over 40% in some regions such as Ringkjøbing and Ribe) [12, 13]. Much of the decline in agricultural groundwater abstractions over the period 1998-2003 compared to 1989-97 was due to higher precipitation [13]. But while water consumption declined the area with irrigation rights rose by 3% between 1990-92 and 2001-03, and accounted for 17% of total farmland in 2001-03. However, the area actually irrigated is about half of the area with irrigation rights, with cereals, potatoes and fodder crops accounting for the major share of the area irrigated [14].

Agriculture's pressure on water bodies has been lowered considerably, and slowly this has led to moderate improvements in water quality from the 1990s up to 2004 [13, 15]. A key challenge has been to reduce and minimise pollution of groundwater as it supplies 95% of national drinking water. Avoiding the environmental degradation of rivers, lakes and marine waters is also important. The main agricultural water pollutants are nutrients and pesticides, but there are also growing concerns with water pollution by heavy metals and micro-pollutants derived from farming [16].

Agricultural nutrient surpluses have fallen from 1990-92 to 2002-04, by 32% for nitrogen and 36% for phosphorus (surpluses are the quantity of nutrient inputs minus outputs of nutrients, nitrogen – N – and phosphorus – P). Even so, despite this reduction, nutrient surpluses per hectare of agricultural land remain above the OECD and EU15 averages. Lowering of nutrient surpluses has led to improvements in nutrient use efficiency (the ratio of N/P output to N/P input), and P use efficiency was close to the OECD average in 2002-04, although N use efficiency was below the EU15 and OECD averages. Raising nutrient use efficiency has largely occurred because of enhanced nutrient utilisation of manure by crops and changes to animal feed consumed by livestock [17]. The fall in nutrient surpluses is mainly due to a decline in inorganic fertiliser use (N and P) – among the highest rate of reduction across OECD countries – but also lower livestock numbers (*i.e.* less manure); and reduced nutrient uptake from crops and pasture as production declined [13, 15]. Accumulation of nutrient surpluses is generally: greatest on livestock rather than crop holdings; increases with rising livestock density per hectare; and is higher for pig than cattle holdings in the case of P, but the opposite for N [13]. Under the APAE's it is compulsory for farmers to adopt nutrient management plans, while the whole country is designated as a vulnerable zone under the EU *Nitrate Directive*. The APAE's have encouraged an: increase in the storage capacity of manure; a greater share of manure being spread in spring and summer rather than winter, and an improvement in manure handling and spreading practices to increase utilisation of manure [15, 18].

Despite declining farm nutrient surpluses agriculture is the main cause of eutrophication in water bodies. Agriculture accounts for 76% for nitrogen (N) and 27% for phosphorus in 2003 [13], reflecting the greater reduction in industrial and urban point sources of nutrient pollution than for agricultural diffuse pollution [6, 19]. Measurement of agricultural nitrate run-off and leaching (in the root zone) shows a reduction of 42% in clay soils and 52% in sandy soils between 1990 to 2003, but no trend has been detected for losses of total phosphorus from farmland [13, 15]. As a result there was a reduction of nitrate in ***rivers*** by 30% between 1989-2003 mainly due to reduced run-off and leaching from agriculture. For ***lakes*** the leaching of phosphorus from farmland is now the main source of pollution, and leaching is 2-3 times higher from cultivated compared to uncultivated land [13]. However, agricultural N and P into lakes have decreased significantly between 1989 and 2003 [13]. The problem of ***groundwater*** pollution is largely

due to elevated nitrate concentrations from farmland [13]. The mean nitrate concentration leaching into groundwater from farms was close to the 50 mg nitrate/litre limit value for drinking water, but in wells and shallow aquifers it has decreased. Nitrates in aquifers have been mainly located in the so called "nitrate belts" in North Jutland and West Zealand [20]. For ***marine waters*** there are signs that nutrient concentrations in coastal waters have begun to decrease and algal production is being limited, attributed to both lower run-off from agricultural land and point sources of pollution into rivers [13, 15]. Agriculture contributed nearly 90% of nitrogen in marine waters and 35% of phosphorus in 2003 [13].

The cost of reducing agricultural nutrient pollution has been considerable and led to a sharp increase in the price of water for household users [21]. The overall cost of APAE II (1998-2003) of which farmers have paid 60% of the costs ,was estimated at DKK 525 (USD 65) million or DKK 15 (USD 2) per kg of avoided nitrogen leaching annually, achieved through altering management practices and changes in land use, such as forest and wetland development [6, 22, 23, 24]. Household water prices (pre-tax) rose by 58% between 1988 and 1999, in part to cover the costs of removing nutrient discharges from water [21]. A range of measures were used under APAE II to reduce farm nitrogen leaching with their cost effectiveness varying from an average per kg reduction in nitrogen (N) leaching of DKK 7 (USD 0.9) per kg N for the creation of wetlands to over DKK 75 (USD 9) per kg N for limits on livestock density [23, 24]. But the economic benefits from lowering farm nutrient loads are currently unknown, although the physical loads of nutrients have been lowered significantly [6, 21].

There was a nearly 40% reduction of agricultural pesticide use (active ingredients) from 1990-92 to 2001-03, among the highest rate of decrease across OECD countries (Figure 3.6.2). Agriculture accounts for the major share of pesticide use, about 85%, with the rest used for forestry, urban gardens, road and railway edges [7, 13]. Under the first PAP the objective was to reduce pesticide sales (active ingredients) by 50% in 2003 relative to 1981-85 levels which was achieved [15]. The annual frequency of pesticide application also declined from around 2.5 to 2.2 times per annum from the early 1990s to 2004 (an indicator of spraying intensity and the overall environmental impact of pesticides) [12, 15]. The *Bichel Commission* set up in 1999 to evaluate the first PAP concluded that the treatment frequency could be reduced over a 5 to 10-year period without any major economic impact on farmers [25], with its conclusions supported by other research [26]. The main reasons for the decline in pesticide use have been: a fall in crop area; the use of the pesticide tax; the growth in organic farming; greater use of low-dose products; and improved pest management, including better pesticide handling and disposal [6, 7, 27]. Research suggests that the use of the ***pesticide tax*** is a relatively cost effective measure in reducing total pesticide use. However, if the objective is to improve the conditions of wildlife habitat then the use of pesticide free buffer zones may be a more effective measure, although more expensive than a tax [28].

Organic farming grew rapidly over the 1990s, peaking in 2002 at about 7% of the total agricultural land area and numbers of farms, encouraged by rising organic food prices and payments to cover the costs of conversion [29]. But from 2003 to 2006 organic farming has been in decline mainly because of lower prices and the possibility for farmers to receive similar environmental payments without changing to an organic status if fertiliser use is restricted and pesticides are not applied [29, 30, 31, 32]. However, demand for organic products is rising, while support for organic producers continues.

Frequency of pesticides found in groundwater monitoring sites was stable between 1996 to 2002, but increased slightly over the period 2003 and 2004, despite the large cut in pesticide use over the 1990s (Figure 3.6.3) [15]. Even so, the share of wells exceeding drinking water standards in 2004 was the lowest since 1995, with the standard exceeded in 5% of wells, although pesticides were detected one or more times in 69% of upper groundwater [15]. Less than 1% of human intake of pesticides derives from drinking water [25]. The increasing detection in the share of wells affected by pesticide pollution is not linked to greater contamination but rather to the larger number of pesticides that are being monitored. There is evidence, however, that some pesticides (*e.g.* Glyphosate) can be retained in the soil and gradually released into groundwater over many years [33]. Pesticides are widely detected in rivers and lakes, especially Roundup and Glyphosate, although the overall knowledge of the impact of pesticides on terrestrial and aquatic ecosystems in Denmark is poor [13, 15, 25]. Under the PAP about 8 000 hectares of spray-free zones have been created along rivers and lakes [6]. Air deposition of pesticides from spraying is greatest in spring and autumn, but in general deposition levels are low and considered not to have any acute toxic effects [15]. Recent research suggests, however, that harmful impacts of pesticide spray drift on hedgerows could be significant a year after exposure [34].

Agricultural pollution of water from heavy metals, hormones and pathogens are a growing concern. Monitoring sites of young and shallow groundwater in agricultural catchments reveal that from 1998 to 2003 Maximum Admissible Concentration standards for heavy metals have been exceeded in 32% of the sites with intensive agriculture, with many high values for nickel, zinc, and lead [13, 35]. Estrogens with potential to cause endocrine (reproductive) disruption in aquatic species have recently been shown to have leached through agricultural soils, especially from manure or sewage sludge used as a fertiliser, but a recent survey found very low or even no estrogenic activity in investigated field drains and at levels in water below those which can cause feminisation in fish [36, 37]. Pathogenic bacteria (virus, bacteria, protozoa) have also been quantified in high numbers in drains below agricultural land on which manure and sewage sludge has been spread [35].

Despite the reduction in agricultural ammonia emissions over the past decade, a further large decrease is necessary to meet national commitments under the *Gothenburg Protocol*. Between 1990-92 and 2001-03 agricultural ammonia emissions were cut by 20%, compared to a reduction of 7% for the EU15 on average. Denmark is committed to lowering total ammonia emissions to 69 000 tonnes by 2010 under the *Gothenburg Protocol*. By 2001-03 emissions were 105 000 tonnes, hence a cut of 52% will be required to meet the target. Farming accounts for 98% (2001-03) of ammonia emissions, largely from manure and to a lesser extent inorganic fertiliser use [38], with the contribution of ammonia to total acidifying gases over 40% in 1997 [39]. The annual deposition of nitrogen (N) on land and marine waters varied from 7-24 kg N/hectare in 2003 [13], with the highest levels of deposition up to 100-200 kg N/hectare in areas with large intensive livestock farms [8]. However, almost 75% of the total nitrogen deposition on the Danish landmass is derived from foreign sources, with the remainder largely from Danish agriculture [13].

Agricultural greenhouse gas (GHG) emissions decreased by 21% between 1990-92 and 2002-04. This compares to a reduction of 3% in total GHG emissions across the country and 7% for the agricultural GHG emissions of the EU15 over this period. Denmark has a commitment under the *Kyoto Protocol* to make a total GHG reduction of 21% by 2008-12 as part of the EU *Burden Sharing Agreement* [40, 41]. The share of farming in total national GHG

emissions is nearly twice the OECD average at 14% in 2002-04. GHG emissions from agriculture are not taxed, unlike the rest of the economy. The main sources of GHGs are methane from livestock manure and nitrous oxide from fertiliser and manure applied on soils [40, 41]. The reductions in GHGs are particularly associated with measures taken under the APAE's which have led to a substantial decrease in nitrogen, with a resulting co-benefit in lowering GHG emissions [40]. The downward trend of agricultural GHGs is projected up to 2008-12, and is expected to originate from: CAP reform; the third APAE; establishment of ammonia reduction initiatives for livestock; higher biogas production from livestock slurry; and a further decline in livestock numbers and fertiliser use [40, 42]. ***Agricultural mineral soils are estimated as a net sink of CO_2*** over recent decades because of the ban on field burning of straw and an increase in set-aside and catch crops, although this has been partly offset by cultivation on organic soils [41]. Also, payments for the afforestation of farmland led to 12 000 hectares converted to forestry between 1990 and 2004, resulting in a corresponding reduction of CO_2 [40, 42].

The fall in direct on-farm energy consumption of 24% compared to a rise of 7% across the economy over the period 1990-92 to 2002-04 has also helped lower carbon dioxide (CO_2) emissions, with agriculture accounting for 5% of total energy consumption (2002-04). Fuel use by agriculture is projected to further decrease over the period 2005 to 2030 [43]. Agriculture also produces ***renewable energy***, mainly biogas from treatment of livestock slurry currently providing CO_2 equivalent savings of about 4% of total agricultural GHG emissions, with projections indicating these savings could be doubled up to 2010 [40, 42]. ***Biogas production*** grew because of government incentives and the increasing need for farmers over the 1990s to dispose of nitrogen waste under the APAE's [10]. Consequently the number of biogas plants, both centralised plants serving many farms and farm scale plants, rose rapidly over the 1990s, but recently the expansion of new plants has slowed [10].

The pressure from agriculture on biodiversity continued over the 1990s, with adverse impacts from eutrophication of ecosystems, drainage of ponds and marshes, habitat fragmentation and overgrowth or inadequate grazing of meadows, grasslands and heaths [44]. But there are positive signs that the pressure may be easing. Reductions in agricultural nutrient surpluses, pesticide use and air emissions, as well as increasing areas of uncultivated habitats on farmland, have together lowered agriculture's pressure on biodiversity. Trends in the diversity of ***agricultural livestock genetic resources*** (there is no information for crops), reveal that the number of livestock breeds registered or certified for marketing increased during the period 1985 to 2002. The number of endangered and critical livestock breeds (cattle, poultry, pigs, sheep, horse and goat breeds) fell from 13 in 1990 to 5 by 2002, with the number of breeds under conservation programmes over the same respective period rising from 2 to 12 [12]. But the overall status of *in situ* or *ex situ* plant and livestock conservation is unclear.

Semi-natural farmed grasslands and meadows host nearly 700 species that are acutely threatened, vulnerable or rare, but monitoring overall trends in wild species is infrequent [12, 44, 45]. For common farmland birds (*i.e.* Skylark, *Alauda arvensis*; Lapwing, *Vanellus vanellus*; Barn Swallow, *Hirundo rustica*; Partridge, *Perdix perdix*; and Corn Bunting, *Miliaria calandra*), populations between 1990 and 2004 remained near stable and increased in some cases (*e.g.* Corn Bunting) [12, 46]. This compares with many other EU15 countries where farmland bird populations have declined despite agriculture being subject to similar structural changes and policy influences as Denmark [46]. The explanation for this is unclear although it is likely that the reduction in nutrient loadings and pesticide use,

together with the increase in the area of small uncultivated habitats on farmland (*e.g.* hedges, field margins) has been significant in stabilising Danish bird populations [46]. Recent Danish research suggests that while changes in pesticide use have an important impact on wildlife it is not the most significant factor, as increasing uncultivated habitats and maintaining a diverse farm landscape structure can be of greater importance in providing food resources for wildlife [47].

Other wild species linked to farm habitats or impacted by farming activities have shown mixed trends since 1990. Deer (*Capreolus capreolus*) numbers increased, possibly linked to an expansion in the area of winter crops and fallow land over the past decade, although the numbers of hare (*Lepus europaeus*) have declined [12]. For the fire-bellied toad (*Bombina bombina*) farming practices have possibly reduced the annual survival rates of adult frogs, with 80-94% survival rates found on natural habitats compared to 55-60% in cultivated areas. The lower survival rates for toads on farmed areas is attributed to disturbance from heavy machinery and the use of pesticides and fertilisers [48].

It is difficult to identify an overall trend for changes in the extent and quality of farmed habitats since 1990. This is because of diverging trends in different types of farmed habitats and also due to limited monitoring [45]. While the reduction of nearly 5% in the total area farmed was close to the EU15 average over the period 1990-92 to 2002-04, the decrease in area of ***permanent pasture*** of 17% over the same period was among the highest rates of reduction across OECD countries. The implications for biodiversity are unclear as about half the land converted from farming to other uses during this time was for urban and industrial uses, and much of the remainder converted to forestry [12]. The ***afforestation*** of farmland has been encouraged under the APAE primarily to help reduce leaching of nutrients and pesticides, but also provide other environmental services such as carbon sequestration, biodiversity and landscape benefits [49]. At a more disaggregate level there has been a decline in ***semi-natural farmed habitats***, notably dry grassland and fresh meadows at a more rapid rate of decrease, especially between 1995 and 2000 than for marshlands and moors (Figure 3.6.4) [12]. A further concern is that the absence of low intensity grazing in some areas could lead to the invasion of woody plants to the detriment of habitats [15]. An indicator of the woody plant coverage of dry grasslands has revealed that coverage was high at many monitoring sites on grasslands, although variation between sites was considerable, but there are insufficient data at present to identify the trend in woody plant coverage [15]. For smaller ***uncultivated habitats or biotopes on farmland*** there has been an overall increase between 1991 and 1996, including for hedges, wet ditches and solitary tress, but a decline in the number of dry ditches. While the trends in the quality of these habitat and landscape features are unknown, there is the possibility of greater homogenisation of the farmed landscapes with larger field size, and habitat fragmentation from increased paved and soil road length [12].

Biodiversity is affected by eutrophication mainly caused by agriculture, especially as a high share of native Danish flora is sensitive to excessive nitrogen [45]. Moreover, a large number of endangered species have a preference for nitrogen impoverished habitats, while many alien species to Danish flora thrive under nitrogen rich conditions [45]. With the decline in agricultural ammonia emissions and other sources of acidification, pressure on nitrogen sensitive ecosystems has eased. Even so, ammonia emissions are a major threat to ecosystems, including semi-natural grasslands, meadows, fens, bogs and heaths [8]. Nitrate concentrations are low in raised bogs and mires, but the soil carbon to nitrogen ratio (which when low indicates pollution of natural habitats with nitrogen) is low for wet

and dry heaths and grasslands, which could be detrimental to plant communities not tolerant of high nitrogen levels [15]. However, the status of the Marsh Fritillary (*Ephydryas aurinia*), a butterfly that inhabits humid heaths and unfertilised meadows, improved between 2000 and 2004 [15], which may be a positive sign of reduced eutrophication.

3.6.3. Overall agri-environmental performance

Overall the pressure on the environment from farming has declined since 1990, despite an increase in livestock production. The decoupling of environmental pressure from changes in farm production is highlighted with reductions in nutrient surpluses, pesticide use and emissions of ammonia and greenhouse gases. However, the absolute level of nitrogen surpluses is well above the OECD and EU15 average. Moreover, farming remains the major source of nutrients in water, and pressure on biodiversity continues, especially ecosystem eutrophication. The cost of reducing agricultural water pollution is high and while farmers have borne some of the costs (including adjustment costs due to changes in farm management practices), taxpayers have covered the major share. Also household water charges have risen, in part, to cover the cost of removing nutrients from water supplies [21].

Denmark has an extensive environmental monitoring system which includes agriculture. This system, starting in the late 1980s, is particularly well developed for tracking agricultural nutrients in water bodies [13, 15, 16]. The monitoring programme, at a cost of about DKK 229 (USD 37) million (2004 prices) annually, collects annual data in five agricultural water catchments that have an important influence on policy making [5]. The annual fertiliser and manure accounts, and applications for single payments cover a major share of Danish farms and provide information on crops, fertiliser use, manure production and use, etc. This information is used by national research and farmer organisations to track developments and as a basis for Geographical Information System development. Environmental monitoring has been supported by studies evaluating the economic and administrative costs of policies aiming to reduce agricultural pollution of water and ecosystems [5, 7, 20, 22, 23, 24, 25, 28, 50], although there are fewer studies valuing the benefits [51]. Efforts are being made to improve monitoring [52], but knowledge and monitoring of agricultural impacts on the environment are poor in a number of areas, including: the impact of pesticides on ecosystems; changes in the genetic diversity of farm crops; while monitoring of overall trends in farmed habitats and wild species associated with agriculture is weak and infrequent [44].

There has been a continuous strengthening of agri-environmental measures since 1990. This has led to improvements not only for reducing agricultural pollution of water bodies but also co-benefits for other environmental concerns, such as lowering GHG emissions and for biodiversity conservation. Danish research has linked much of the reduction in agricultural nutrient surpluses to the implementation of the APAE's since 1987 [5, 6, 19]. However, the target under the APAEs was for a decrease of loading into aquatic environments by 50% for nitrogen and 80% for phosphorus between 1988 and 2002, and while point sources of nutrient pollution were lowered in excess of the targets, this was not the case for agriculture where reductions fell short of the target [6, 19]. But under APAE II there was a reduction of 49% in nitrogen leaching, even with the readjustment to a higher base period for the reference year 1985, and research indicates that the fertiliser and manure related tools have been effective in reducing pollution [23]. The government's quality objectives have been met for marine waters in the North Sea and Skagerrak, but for other marine waters compliance with environmental quality standards requires a further reduction in nutrient inputs, especially from agriculture [13].

The government's target to reduce pesticide use by 50% (from 1981-85 levels) under the PAP was achieved by 2003, and there has not been much improvement in pesticide treatment frequency over the period 2003-05 [6]. Research reveals that while the PAP contributed significantly to the declining use of pesticides over the past 15 years, other factors were also important including the reduced crop area, the expansion in organic agriculture, and improved pesticide technologies and management [6, 7, 27]. In April 2006 the government further strengthened regulations to better control and inspect farmers handling and management of pesticides, including use of spraying equipment [53]. In contrast to many other EU15 countries where ***farmland bird populations*** have declined, those in Denmark remained stable between 1990 and 1999, but then declined up to 2004 [12, 46], although similar agricultural structural changes and policy influences occurred in those other countries. But it is likely, although the causality is not fully understood, that the major reductions in nutrient loadings and pesticide use, together with the increase in area of small uncultivated habitats on farmland has been significant in stabilising farmland bird populations [46].

Despite the progress in agri-environmental performance a number of challenges remain. There has been a ***decline in semi-natural farmed habitats*** (notably dry grasslands and meadows) which are habitats for about 700 threatened and rare species. In addition, the invasion of woody plants in some locations due to the disappearance of low intensity grazing is a concern for the conservation of these habitats, although the increase in uncultivated habitats on farmland (*e.g.* hedges, ditches), however, is likely to help biodiversity conservation. There are also plans over 2007 to 2009 to increase expenditure on the restoration of wetlands, mainly restoring small rivers.

The process of reducing agricultural nutrient pollution of the environment has been difficult and slow, highlighted by the failure of agriculture to meet the government targets under the APAEs, although some success was apparent under APAE II (as noted above) [4]. While the third APAE has set ambitious targets to further reduce nutrient leaching from agriculture by 2015, but it may be difficult to attain the targets set in the EU *Water Framework Directive* with current measures [54]. Agricultural nitrogen use efficiency is well below the OECD average efficiency level, while recent Danish research on pig farms also found widespread environmental inefficiencies with considerable potential for improvement [55]. Further efforts are required to quantify the benefits of different nutrient reduction and management policies which would assist policy makers [4, 21].

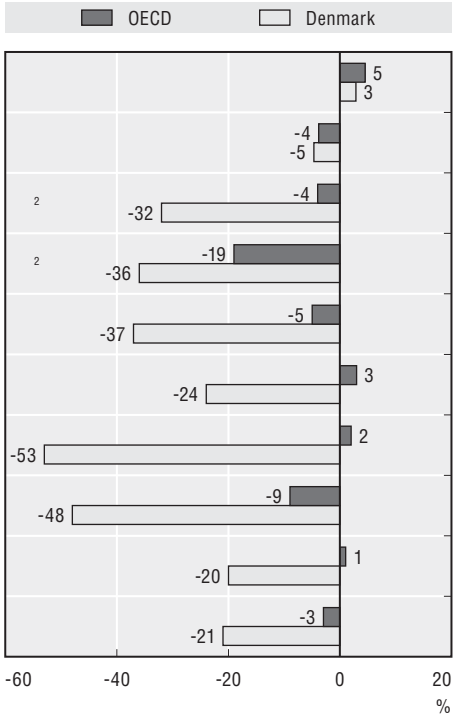
Linked to the need to reduce nutrient surpluses is further lowering agricultural ammonia emissions, which under the *Gothenburg Protocol* requires a reduction of nearly 50% over the next 10 years (2001 to 2010), compared to decrease of 20% achieved over the previous 14 years (1990-92-2001-03). However, reducing the impact of ammonia emissions and deposition, ranging from international, national and highly localised sources (livestock farms) on dispersed nitrogen sensitive ecosystems remains a challenge. Policies aimed to meet this challenge were implemented from January 2007, with a reduction of ammonia emissions integrated into the compulsory approval of livestock farms. Current projections suggest that Denmark with these initiatives, could meet the *Gothenburg Protocol* target in 2010 [8].

The decrease in agricultural GHGs achieved over the 1990s is projected to continue a downward trend to 2008-12 [40, 42]. Reductions in GHG emissions are likely to derive from lower livestock numbers and fertiliser use and actions under the third APAE, as well as

from increasing biogas production. However, the termination of the *Biogas Action Programme* in 2002 and limited availability of organic waste has resulted in an uncertain future for biogas [10]. Against a benchmark of DKK 120 (USD 18) per tonne CO_2 equivalent (CO_2-eq.) set by the Government in 2003 (considered as the likely international price of emission quotas/credits) reducing GHG emissions through measures that seek to reduce fertiliser use, cut ammonia volatilisation and decrease nitrate leaching are estimated to result in costs of DKK 400-600 (USD 60-90) per tonne CO_2-eq., while measures encouraging energy crops, biogas and changes in cattle feeding regimes are calculated to have costs below the government benchmark [41]. Exemptions for farmers from ***energy and climate change taxes*** acts as disincentives to further limit on-farm energy consumption, improve energy efficiency and reduce GHG emissions, in particular as the general rise in energy and fuel taxation across the rest of the economy has been shown to lead to reductions in GHG emissions [40].

Figure 3.6.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

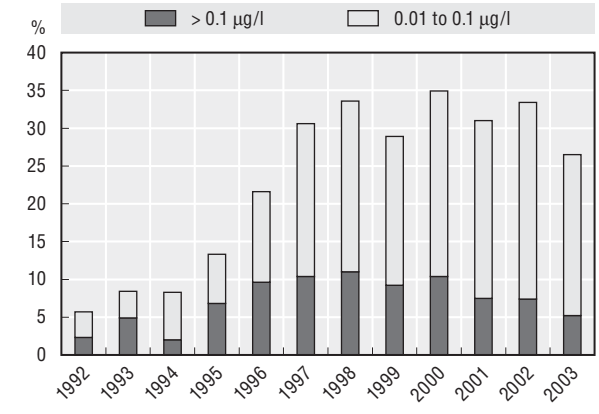
Variable	Unit		Denmark	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	103	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–132	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	127	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	11	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–1 817	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–252	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–202	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	0.4	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–26	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–2 750	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

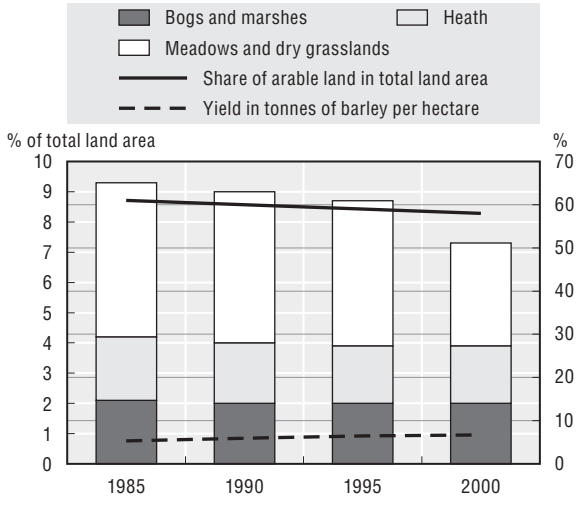
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.6.3. **Share of monitoring sites with occurrences of pesticides in groundwater used for drinking**



Source: GEUS, Groundwater Monitoring 2001.

Figure 3.6.4. **Share of meadows and dry grasslands, heath, and bogs and marshes in the total land area**



Source: Statistics Denmark, the National Forest and Nature Agency.

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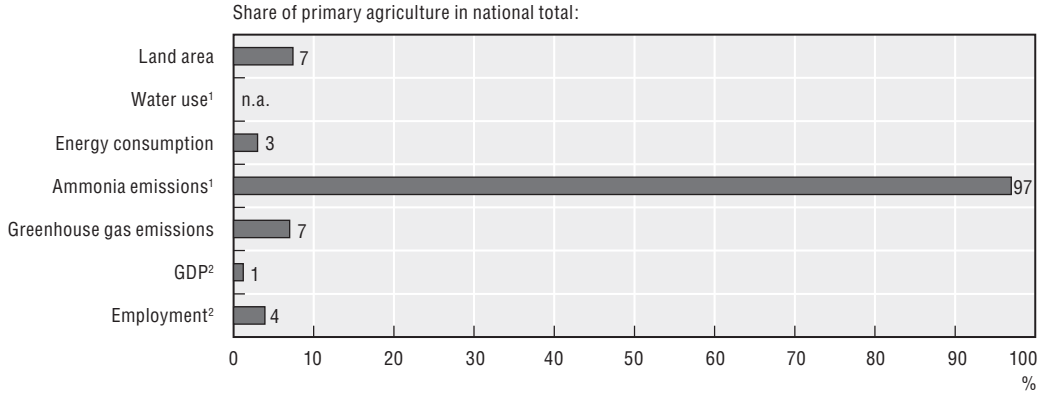
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3.7. FINLAND

Figure 3.7.1. **National agri-environmental and economic profile, 2002-04: Finland**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.7.1. Agricultural sector trends and policy context

Primary agriculture's contribution to the economy is small and declining, accounting for 1.2% of GDP and 3.9% of employment in 2004 [1] (Figure 3.7.1). Agricultural productivity improved at around 1% annually between 1992 and 2003, with production remaining about stable (reflecting rising crop production largely offset by declining livestock output) and reduced input use [1, 2, 3, 4]. The intensity of farming has diminished with the area farmed over the period 1990-92 to 2002-04 declining by 12%, one of the largest decreases across the OECD, with even larger reductions in purchased farm input use: nitrogen (–20%) and phosphorus (–60%) inorganic fertilisers; pesticides (–9%); and on-farm direct energy consumption fell by 12% (Figure 3.7.2).

Finland's accession to the EU in 1995 brought major price and structural changes to farming [1, 2, 3, 4]. In 1995 while producer prices declined by 40-50%, although for milk the reduction was 15%, the decrease in input prices was less dramatic [1, 3, 4]. Also the average farm size has increased as their number declined, and a third of farmers are full time. The climate limits farm production, and the share of agricultural land is only 7% of the total land area, among the lowest share across the OECD, with crop production largely in the south, whereas livestock farming is concentrated in the central, eastern and northern regions [1, 5]. As agriculture is largely rain-fed, use of total water resources is extremely limited with irrigation, mainly for vegetables, accounting for only 4% of total farmland in 2000 [6, 7].

Farming is mainly supported under the Common Agricultural Policy (CAP) with support also provided through national expenditure within the CAP framework. Support to EU farmers has on average declined from 41% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate – PSE) compared to the 31% OECD average. Nearly 70% of EU support to farmers is still output and input linked (compared to over 90% in the mid-1980s), which are the forms of support that most encourage production intensity. Finnish accession to the EU brought a considerable reduction in farm support with the EU PSE 50% compared to 67% for Finland in 1994 [8]. Finland's national expenditure to support farming was around EUR 1.0 (USD 1.25) billion and in conjunction with EU co-financing amounted to EUR 1.8 (USD 2.25) billion in 2004 of which about a third is allocated to agri-environmental schemes [1]. Agri-environmental support accounted for a third of total government environmental expenditure in 2004 [9].

Agri-environmental policies seek to reduce environmental damage and promote biodiversity and landscape conservation. The main agri-environmental measure is the Horizontal Rural Development Programme (HRDP, 2000-06) based on the EU Rural Development Programme [10, 11], with a new *Rural Development Strategy and Programme for 2007-13* approved by the EU Commission in June 2007. The key emphasis of the HRDP is on water protection, but measures also aim to limit air pollution, reduce pesticide risks, and promote conservation of biodiversity and cultural landscapes [12]. The HRDP consists of mandatory basic and additional measures (*general schemes*) and special measures (*specific schemes*). *General schemes* provide payments (EUR 259 [USD 324] million in 2004) for the adoption of nationwide agri-environmental practices, such as nutrient and pesticide management plans, creation of filter strips, and biodiversity and landscape conservation, with payments varying per hectare per year from EUR 93 (USD 116) for arable crops, EUR 117 (USD 146) for livestock farms, and EUR 333-484 (USD 416-605) for horticultural crops. Over 90% of working farms and cultivated area were covered by general schemes in 2004 [1], with 5% of farms receiving this support monitored to verify that the required measures are being adopted by farmers [6]. *Specific schemes* are more focused and are only provided if commitments under the general schemes have been applied by a given farmer. They provide payments (EUR 39 [USD 49] million in 2004) for covering investment and maintenance costs, such as the establishment of riparian buffer zones and wetlands, and promoting organic farming. The government has set a target to increase the area under organic farming to 15% of farmland by 2010, with 7% of agricultural land under organic management by 2004 [5].

Agriculture is influenced by national environmental and taxation policies. There are a number of measures that have economy-wide objectives to reduce eutrophication of water courses [13]. *Water Protection Targets* for 2005 set a 50% reduction target from 1991-95 levels for both nitrogen and phosphorus loads from agriculture. As these targets were not met, a new target for 2015 was agreed in 2007, seeking to reduce nitrogen and phosphorus loads from agriculture by 30% from 2002-05 levels. Under the *Environmental Protection Act* (2000) large-scale agricultural activities may undergo an Environmental Impact Assessment (EIA). The *Water Services Act* (2004) implements the EU *Water Framework Directive*, which for farming involves control of nutrient emissions under the EU *Nitrates Directive*, with action plans established at the water catchment level [1, 14]. A pesticide tax is levied on the pesticide industry, rather than farmers, averaging EUR 2 (USD 2.5) million annually to cover the administrative costs of registering new pesticides and improving pesticide productivity [9, 15, 16]. A tax on phosphorus fertiliser was introduced in 1990, but abolished in 1994 in preparation for entry

into the EU [10]. Policies promoting wood fuel production and agri-environmental management were implemented jointly in the early 1990s to assist rural areas and increase bioenergy production, especially as forestry is an integral part of farming with 95% of working farms having forests [17]. Payments are provided for production of energy crops (*e.g.* reed canary grass – *Phalaris arundinacea*) at EUR 45 (USD 56) per hectare [1]. Producers receiving farm support are entitled to reimbursement of energy (including fuel and electricity) and carbon dioxide taxes [16, 18], which was around EUR 245 (USD 304) per farm, equal to nearly EUR 16 (USD 20) million of budget revenue forgone in 2005.

International environmental agreements important to farming include [9]: those seeking to curb nutrient emissions and pesticides into the Baltic Sea (*HELCOM Convention*) [13]; the *Gothenburg Protocol* concerning ammonia emissions; greenhouse gases (*Kyoto Protocol*); and commitments under the *Convention of Biological Diversity*.

3.7.2. Environmental performance of agriculture

The main agri-environmental issues are water pollution and biodiversity conservation. Water pollution from the run-off and leaching of excess farm nutrients is a major source of degradation of aquatic ecosystems in both inland surface water and marine waters, and to a much lesser extent pesticides. Other agri-environmental issues of importance, include soil quality, emissions of ammonia and greenhouse gases, and conservation of cultural features in agricultural landscapes.

Soil erosion is primarily a concern for its off-farm impacts as a carrier of nutrients to water bodies. Soil water erosion is within the tolerable range and is usually under 1 tonne/hectare/year, reaching a maximum of 3 tonnes/hectare/year in some south-western areas [6, 19]. Although erosion rates are low it is a key factor affecting the quality of water as soil particles transport nutrients, especially phosphorus, to water bodies causing eutrophication and algal blooms [6, 19, 20]. With about 30% of arable land under plant cover or reduced tillage this has led to a decrease in the areas with the highest rates of erosion [6]. But research has shown that with mild winters over the past 20 years in Finland, nutrient loadings into water bodies were substantial and tended to override load reductions from decreased autumn tillage and increased use of green cover [20]. Greater adoption of low till has led to a rise in pesticide use, and potentially an increase in water pollution from their use, because of the need to use pesticides (Glyphosate), as perennial weeds are more abundant under low till than conventional tillage. However, besides reducing soil erosion and sediment bound nutrients, there are other environmental benefits from low till, such as greater soil carbon sequestration and habitat conservation for wild species [21].

The main focus on controlling water pollution has been on agriculture recently, since the control of urban and industrial pollution is well developed. For example, over 95% of phosphorus is removed from wastewater treatment plants [19]. Overall environmental pressure on inland and marine water quality has eased as there has been a substantial reduction of farm pollutants, largely nutrients (nitrogen and phosphorus) and pesticides. But while emissions have been lowered eutrophication of water continues and the state of water bodies has not improved over the past decade [1, 10].

There has been a substantial reduction over the past 15 years in agricultural nutrient surpluses (input minus output of nutrients, nitrogen – N – and phosphorus – P), among the highest reduction across OECD countries. The decrease in the quantity of nutrient surpluses was more significant for P (–65%) compared to N (–42%), with nutrient surpluses per hectare

of agricultural land now below both EU15 and OECD average levels (Figure 3.7.2). As a result of these changes there has been a considerable improvement in nutrient use efficiency (*i.e.* ratio of N/P output to N/P input), and while N use efficiency is now similar to the EU15 and OECD averages, for P use efficiency it is lower. The reduction in nutrient surpluses has been mainly due to the large reduction in nutrient inputs – inorganic fertiliser use and livestock numbers (*i.e.* less manure) – compared to a much smaller rise in nutrient uptake from crops and pasture. Over 90% of agricultural land was under a nutrient management plan in 2001-04, which includes conducting a soil nutrient test on farms once every 4 to 5 years.

Eutrophication of water has become the most serious environmental problem caused by agriculture [10]. Farming remains the single most important source of nutrient loading into water bodies, accounting for around 50% of N and 60% of P [1, 9]. A study for the period 1993 to 1998 estimated that agriculture's N contribution to river catchments varied from 35-85% in the intensively farmed south-west to 0-25% in the north [22]. The proportion of slightly eutrophic waters has increased and signs of early eutrophication have been pronounced in many small rivers, lakes and the Baltic Sea [9, 10, 23]. A study concluded that, annual variation notwithstanding, there has been little or no decrease in nutrient loadings into lakes from agriculture in southern Finland during the period 1976 to 2002 [23]. It is estimated that around 2% of shallow wells (and 1.5% of aquifers) in agricultural regions contained nitrates in excess of drinking water standards in 2002 [6]. The Gulf of Finland is one of the most eutrophied sub-basins of the Baltic Sea with a marked increase in algal blooms and dead zones, and nutrient loadings 2-3 times above that of the Baltic Sea average, although Finland is not among the major polluters of the Baltic Sea [10, 24, 25]. The share of Finnish agriculture in the total Finnish N (P) load into the Gulf of Finland rose from 31% (35%) in 1986-90 to 35% (48%) by 1997-2001, and while the quantity of agricultural N has increased over this period, for P it has declined [6].

Despite large reductions in nutrient surpluses this has not yet led to improvements in water quality (Figure 3.7.3). One reason for this is that caution is required in linking changes in nutrient balances to loading of nutrients into water, because of the importance of other factors, for example, nutrient management, crop rotations, and soil drainage systems [26]. Another reason is the long time lags of reductions in external nutrient loads showing up in changes in water quality because of the accumulation of nutrients in soils, especially for P [27]. Moreover, an increasing share of green set aside land has been converted to cereal production which has resulted in higher P losses [28], and there has been a decrease in the area of perennial vegetation from 34% to 28% of farmland between 1995 and 2002, which is important to slow soil erosion and the transport of nutrients into water [6, 28]. Also restrictions on the timing of manure applications and the pressure of time for farmers in the spring has led to them to spread manure on fields close to the farm, which already have high nutrient levels, rather than more distant fields with lower nutrient levels [17]. This problem is being accentuated with the trend toward the regional concentration of livestock production [17].

Pesticide use rose from the mid-1990s to 2003, although over the period 1990-92 to 2001-03 use declined by 9% (Figure 3.7.2) [1, 9]. The main reasons for the increase in pesticide use is due to the: wider adoption of reduced tillage and direct sowing; an increase in the arable area since the mid-1990s; establishment of buffer strips (and enlarged field boundaries); and a shift to pesticides that are used in larger doses [1, 9, 10, 21]. This trend has to some extent been offset by the major increase in the area under organic farming rising from a share in agricultural land area of less than 2% in the mid-1990s to over 7% in 2004,

among the highest share across OECD countries. The intensity of pesticide use is low compared to many OECD countries, mainly because of climatic conditions, especially colder winters, which limit pest populations. As a result the detection of pesticides in watercourses is infrequent and low, with an estimated 0.1-1% of active substances causing water pollution [10], although there is not yet regular monitoring of pesticides in water courses.

Agricultural ammonia emissions decreased by 13% between 1990-92 and 2001-03, a rate of reduction higher than achieved for the EU15 on average (–7%) (Figure 3.7.2). Farming accounts for almost all ammonia emissions (97% in 2001-03), largely from manure management and inorganic fertiliser use. The reduction of nitrogen fertilisers and livestock numbers over the past 15 years has been the main reasons for the decline in emissions. Finland has agreed to cut total ammonia emissions to 31 000 tonnes by 2010 under the *Gothenburg Protocol*, and by 2001-03 emissions totalled 33 000 tonnes, so a further 7% cut will be required to meet the target. While it is likely that the reduction in farm ammonia emissions has contributed to an overall decline in acidifying pollutants, easing pressure on ecosystems (terrestrial and aquatic) sensitive to excess acidity, there is little research or data on this issue.

There was a 14% decline in agricultural greenhouse gas (GHG) emissions between 1990-92 and 2002-04 (Figure 3.7.2). This compares to the 12% growth in GHG emissions from other sources across the country over this period, and a reduction in EU15 agricultural GHG emissions of 7%. The Kyoto commitment requires Finland under the EU *Burden Sharing Agreement* to stabilise total GHG emissions at 0% by 2008-12. In 2000-02 farming accounted for 10% of total GHG emissions, mainly methane and nitrous oxide [1, 29]. Agricultural emissions reductions are largely a co-benefit from decreasing nutrient loadings into the environment, including lower livestock numbers, reduced use of fertilisers, and improved manure management [29]. Even so, the increase in livestock numbers reared in slurry-based manure management systems, compared to solid storage or pasture, has led to a slight rise in methane but a reduction in nitrous oxide emissions. With the projected continued contraction of farming, the downward trend of agricultural GHGs is expected to persist up to 2010 [29]. ***Carbon sequestration in agricultural soils*** has the potential to reduce GHG emissions. With the increase in low tillage on cropland there was a small rise in GHG removals between 1990 and 2003 [29].

The reduction in on-farm energy consumption of –12% compared to a rise of 18% across the economy over the period 1990-92 to 2002-04 has also helped to lower GHG emissions, with agriculture accounting for 3% of total energy consumption (Figure 3.7.2). In 2005 the first large-scale agricultural biogas power plant was opened in Vehmaa, processing liquid manure from 20 pig farms [1]. In 2006 there were 17 000 hectares of energy crops, which is less than 0.5% of total arable land, but the area is expanding rapidly. Research suggests that production of reed canary grass for bioenergy, for example, is only profitable if located between 50-100 kilometres from the energy plant, but could provide environmental benefits not only in terms of lower GHG emissions, but also by reducing nutrient run-off and by replacing the use of peat for energy [3, 30].

The state of farmland biodiversity deteriorated over the period 1990 to 2004 [1, 31, 32, 33, 34]. There are, however, positive signs that recently the pressure from farming on biodiversity are easing, for example, for butterfly species (see below). Protection of Finnish ***agricultural genetic resource diversity***, domestic plants and livestock breeds, combines both *in situ* and *ex situ* conservation [34, 35]. The diversity of most crop varieties and livestock breeds used in

production increased over the period 1990 to 2002. All nine "endangered" and "critical" livestock breeds (cattle, poultry and sheep breeds) were by 2004 maintained under *in situ* conservation programmes, compared with only two in 1985, while for crops there are limited areas of *in situ* conservation for certain fruit, berries, cereals and grass varieties [34]. Finland contributes plant material to the Nordic Gene Bank, while the *National Animal Genetic Resources Programme* finalised in 2004, covers *ex situ* conservation for livestock [34, 35].

Overall there has been a reduction in the abundance and richness of wild species associated with agriculture [1]. Around 25% of Finnish wild flora and fauna species use agricultural land as habitat, with nearly 30% of endangered species found in farmed habitats [36]. A comprehensive evaluation of threatened species associated with farmland habitats in 1985, 1990 and 2000, showed an increasing number of species under threat across five taxonomic groups – *Lepidoptera* (*e.g.* butterflies and moths), *Coleoptera* (*e.g.* beetles), *Hymenoptera* (*e.g.* bees, ants), vascular plants (*e.g.* ferns) and macro-fungi – although the increase was partly due to improved monitoring [31]. Moreover, the latest survey in 2000 showed a rise in the number of threatened species that was higher than in earlier years [37]. There is, however, great variation in the numbers of threatened species across different types of farmland habitats, with almost 50% of them species of dry meadows, and a further 25% found on marginal agricultural habitats, such as field boundaries and field and forest margins [31]. About 20% of all endangered plant species are found in agricultural habitats, but around 60% of these species are threatened by the disappearance of pasture or forest pastures following the cessation of grazing and mowing [33, 38].

Overall populations of many farmland birds also declined from the late 1970s to 2005, although this masks trends of individual species, as some bird species numbers have risen [33, 37]. The decrease in numbers of certain bird species is of particular importance as Finland is host to some of the largest European populations of the threatened ortolan bunting (*Emberiza hortulana*), northern wheatear (*Oenanthe oenanthe*) and whinchat (*Saxicola rubetra*) [39]. The deteriorating trend in bird populations on farmland habitats is also apparent for other species, including insect pollinators, and dung beetles [33, 40]. For butterflies, however, monitoring data for the period 1999 to 2006 indicate an increase in grassland and field margin butterfly species (Figure 3.7.4).

Changes in the quality of semi-natural farmed habitats is a key reason for the decline in wild species linked to agriculture [1, 31, 33]. But other factors are also important in leading to adverse impacts on wild species including: changes in cropping patterns (*e.g.* increase in the area of spring cereals and reduction of winter cereals); greater use of sub-surface drainage which has led to the removal of ditches [1, 39]; effects of pesticides; and the lack of economic incentives for farmers to provide ecosystem services [41]. During the 1990s up to 2004 the area of ***semi-natural extensive pasture*** increased by about 15 000 hectares less than 1% of the total agricultural land area in 2004, largely because agri-environmental payments have encouraged their conservation [6, 36]. But while the total area of pasture has expanded, there are concerns that its quality has diminished, including the fragmentation of pasture into patches, and diminution in the diversity of different types of pasture (*e.g.* loss of fen meadows, forested pasture) [36]. There has been a decrease in the area (number/length) of ***small scale habitats*** on farmland which serve as important habitats for wild species and can provide benefits in terms of the visual landscape. In particular, the loss of open ditches (due to the expansion of sub-surface drainage), small woodland patches within fields, and field boundaries (due to larger field sizes), have had adverse impacts on biodiversity and landscape [42, 43]. However, farmers have been given incentives since 1995 to maintain and

develop buffer strips in agricultural landscapes [43, 44, 45]. It is estimated that around 60-90 000 hectares of ***peatland*** are currently in agricultural use, or about 4% of the farmland area [46, 47], with Finland one of the world's richest countries in terms of peatlands [48].

Cultural agricultural landscapes and agri-biodiversity have in general been adversely affected by a lack of grazing of extensive pastures [1, 33, 49]. Research has shown that there are positive effects from low intensity grazing for many plant species in semi-natural pastures in Finland compared to either discontinuing grazing or subjecting these habitats to high intensity stocking levels [50, 51]. For some plant species, including certain rare species, other factors were also important for their survival, such as mowing rather than grazing pasture, the timing of grazing, and the type and breed of grazing livestock [50, 52, 53]. But the increase in tree cover where grazing is discontinued can also be detrimental to plant species rather than the lack of grazing *per se* [51]. However, changes in the grazing system or its abandonment seem less important for bird than plant species [49]. For butterflies and moths where grazing was restored on abandoned pasture, there was little evidence of the colonisation of old pasture species in restored sites. Moreover, species richness and abundance of butterflies and moths was found to be greatest in abandoned pastures [54], and higher with low intensity compared to high intensity grazed pasture [55].

3.7.3. Overall agri-environmental performance

Despite the significant reduction in pollution from agriculture over the period since 1990, this has not been yet reflected in an overall improvement in the state of environment [1]. From 1990 to 2004 there were substantial reductions in nutrient surpluses and ammonia and GHG emissions, in most cases well below the changes for the EU15 and OECD average. While this has helped ease pressure on the environment, the quality of water in rivers, lakes and the Baltic Sea has not improved, but it must be noted, however, that Finland is only one of a number of countries polluting the Baltic. There has been an increase in pesticide use since the mid-1990s, but because of a lack of monitoring the potential impact of greater pesticide loadings on the environment is unclear, although the intensity of pesticide use remains low compared to many OECD countries. There has been a deterioration in the quality and quantity of wild species, and the habitats important to them, in agricultural landscapes, notably semi-natural grassland.

Environmental monitoring has a long history in Finland but tracking agri-environmental performance is more recent [56]. Indicators are used to evaluate the effectiveness of the *Strategy for the Sustainable Use of Renewable Natural Resources*, which encompasses agriculture [57, 58, 59].

Since joining the EU agri-environmental policies have been strengthened. A new agri-environmental support scheme for the period 2007-13 was approved by the EU Commission in June 2007 as part of the 2007-13 *Rural Development Strategy and Programme*. ***Changes in farming practices*** have brought various environmental benefits, such as low tillage helping to reduce nutrient pollution through lowering rates of soil erosion, and improvements in manure management leading to reduced nutrient loadings, ammonia and greenhouse gas emissions. Improved manure management practices has been a factor raising the efficiency of nutrient use, nevertheless, phosphorus use efficiency remains lower than that of many OECD countries. Deterioration of ***biodiversity*** in farming environments has continued, although there does appear to be some recent success in

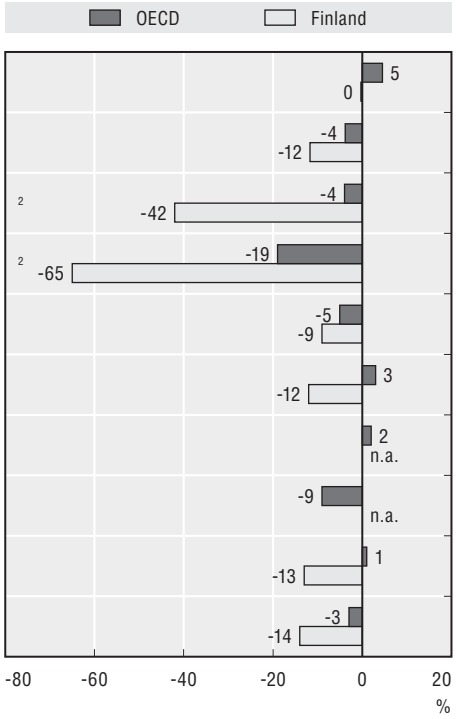
increasing the area of extensive semi-natural grasslands, towards the goal of 60 000 ha by 2010 [1]. But the trend toward greater sub-surface drainage has lead to the removal of ditches, which has been harmful for biodiversity dependent on small scale habitats.

While further improvements in agri-environmental performance are likely some environmental concerns remain. Projections of the agricultural sector to 2013 suggest a further contraction of sector, which is expected to lead to a further concentration of production on fewer and larger farms, while productivity will increase [60]. Some researchers consider there could be trade-offs between fewer but more concentrated and intensive agricultural production and environmental quality, especially stemming from the loss of semi-natural grasslands to non-agricultural uses [61, 62, 63]. Hence, a major challenge facing Finnish policy makers is the conservation of semi-natural grazed grasslands which are recognised as providing biodiversity and cultural landscape benefits.

The mid-term assessment of the Water Protection Targets concluded that even with the implementation of agri-environmental measures the nutrient reduction targets for 2005 could not be reached, despite progress in lowering agricultural nutrient surpluses [7, 25]. As a result of the 2005 target not being reached a new reduction target to 2015 was approved in 2007, seeking to reduce nitrogen and phosphorus loads from agriculture by 30% from 2002-05 levels. Moreover, the nutrients now stored in water bodies will continue to deteriorate water quality for many years, suggesting that action may be required for their recovery [1, 23], especially if Finland is to meet its international commitment to reduce nutrient loadings into the Baltic Sea. Exemptions for farmers from ***energy and climate change taxes*** act as disincentives to further limit on-farm energy consumption, improve energy efficiency and reduce GHG emissions [18]. Given the continuing deterioration of ***biodiversity*** for both flora and fauna [1], some researchers have noted that the uptake of biodiversity conservation by farmers under agri-environmental schemes has been low and the share of government agri-environmental expenditure (12%, between 2000 and 2003) is too low to adequately improve agri-biodiversity [64]. While on the one hand peat production and use of peatlands can have harmful impacts on biodiversity, GHG emissions and water systems, they can on the other hand provide economic and social benefits. The agricultural sector makes a positive contribution to meeting international environment agreement commitments to reduce *ammonia and greenhouse gas emissions*. The contribution of farming in cutting GHG emissions might be further enhanced with the cessation of the agricultural use of peatlands, which potentially could decrease agricultural sector GHG emissions by up to 10% [46].

Figure 3.7.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

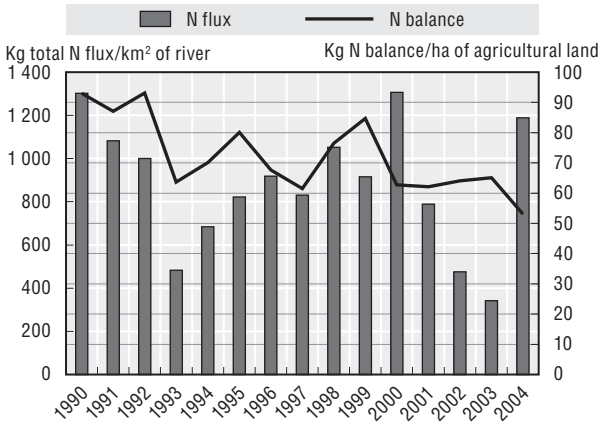
Variable	Unit		Finland	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	100	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–298	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	55	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	8	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–157	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–104	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	n.a.	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	n.a.	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–5	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–922	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

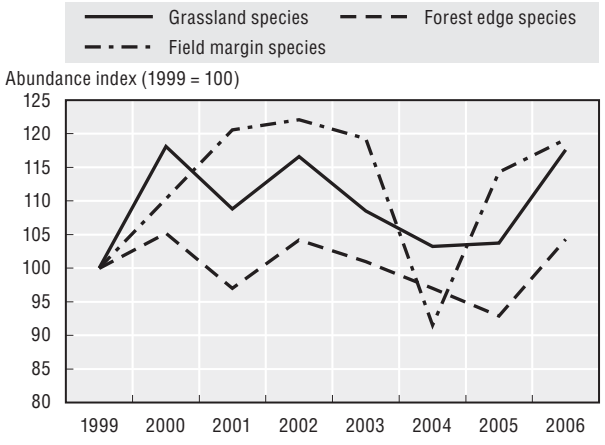
Figure 3.7.3. **Nitrogen fluxes in the Paimionjoki river[1] and agricultural nitrogen balances**



1. The Paimionjoki river is situated in the main agricultural area of Finland.

Source: Ministry of Agriculture and Forestry, Finland.

Figure 3.7.4. **Population trends of Finnish farmland butterflies in three ecological species groups**



Source: Heliola, J., M. Kuussaari and I. Niininen (2007), "Results of the butterfly monitoring scheme in Finnish agricultural landscapes for the year 2005", *Baptria*, Vol. 32 (in press).

StatLink http://dx.doi.org/10.1787/300102623372

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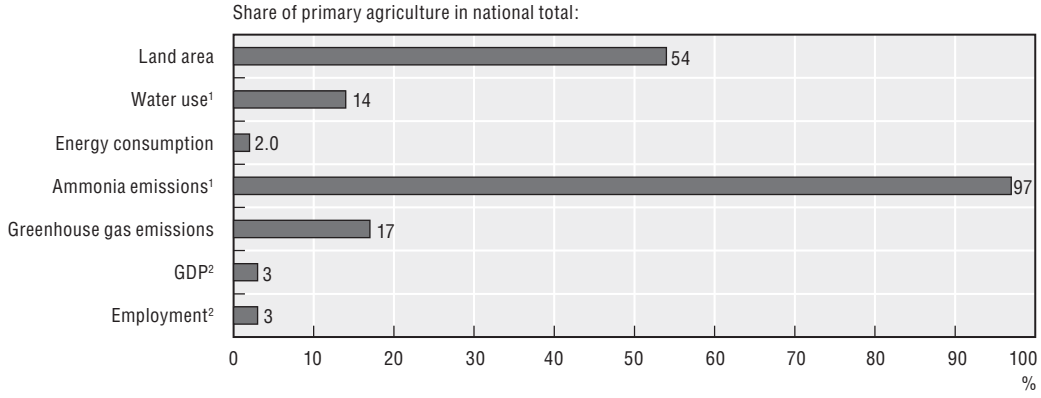
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3.8. FRANCE

Figure 3.8.1. **National agri-environmental and economic profile, 2002-04: France**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2003.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.8.1. Agricultural sector trends and policy context

Agriculture is a significant player in the economy. Agri-food exports accounted for around 13% of total exports, and primary agriculture for nearly 3% of GDP and 3% of employment in 2003 (Figure 3.8.1). The volume of farm production increased slightly by 2% over the period 1990-92 to 2002-04, but purchased farm input use decreased for: pesticides (–10%), although was subject to considerable annual fluctuation; inorganic nitrogen fertilisers (–9%) and phosphate fertilisers (–46%); direct on-farm energy consumption (–9%), and the area farmed declined by nearly 3% (Figures 3.8.2, 3.8.3 and 3.8.4).

France has four broad and highly diverse agro-ecosystems. Northern France is typified by large-scale farming, of both crops and livestock; the west and central regions are predominantly mixed farming regions with grassland and cropping; the south is typically characterised by farming methods influenced by the Mediterranean climate; and the Alpine regions combine mountain farming interspersed with semi-natural areas.

Farming is mainly supported under the Common Agricultural Policy (CAP), with support also provided through national expenditure within the CAP framework. Support to EU15 agriculture has declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate). This compares to the OECD average of 30% [1]. Nearly 70% of EU15 farm support is output and to a lesser extent input linked, but this share was 98% in the mid-1980s. EU and national budgetary support to French farmers is was over EUR 12 (USD 11) billion per annum in the period 2002-04, of which 82% is funded by the EU [2].

National expenditure on agri-environmental programmes increased over the 1990s, and now accounts for 15% of total national agricultural expenditure [2]. The *National Rural Development Plan* aimed over 2000-06 to promote: diversified cropping patterns; crop rotation; and sustainable farming practices, through providing payments to especially encourage, for example, extensive management of pastures, hedge maintenance, and conversion of arable land to grassland [3]. Also, support is provided for integrated farm management; and conversion payments for organic farming, which occupied nearly 2% of agricultural land and increased fivefold between 1996 and 2003 [4, 5]. A programme to control water pollution from livestock effluents covers a maximum of 60% of the costs of constructing manure and slurry storage facilities, as well as all the costs resulting from improving production practices. This programme covers about 50 000 farmers and amounts to EUR 1.28 (USD 1.28) billion over 2000-06, a nine-fold increase since the early 1990s [6]. Support has been provided to voluntary initiatives, such as *Ferti-Mieux*, to encourage improved farm nutrient management, but this support was ended in 2003 [7, 8]. Pollution taxes are levied on nitrates for large livestock producers, based on emission estimates; and on pesticide sales relative to toxicity [leading to pesticide producers paying pollution taxes of EUR 40 (USD 50) million in 2004], while products containing atrazine were banned in 2002.

Farming is subject to economy-wide environmental and taxation measures, and international environmental agreements. A diesel tax concession (about one-seventh of the normal rate) is provided to farmers, worth about EUR 950 (USD 1 190) million annually in terms of budget revenue forgone 2004-06 [1]. Irrigation is supported through subsidised infrastructure capital costs (40% to 85%), equal to around EUR 26 (USD 32) million in 2006, and reduced water charges (about one-fifteenth of household charges) [1, 9, 10]. Commitments under ***international environmental agreements***, such as lowering nutrient loadings (into Lake Geneva, the Rhine, and the North Sea), and ammonia emissions (*Gothenburg Protocol*) also affect farming.

3.8.2. Environmental performance of agriculture

One of the key agri-environmental challenges concerns water pollution. Water pollution is an issue given high priority by public opinion [11]. Meeting the EU *Nitrate Directive*, as well as the requirements of international environmental agreements related to nutrient loadings in coastal water and ammonia emissions, pose a considerable challenge. The overall intensity of farm input use and land use changes are a source of biodiversity stress, while soil erosion and competition between agriculture and other water users are further concerns in some regions.

Although very much localised, soil erosion is increasing in some regions. The off-farm impacts of soil erosion are high, with over 5 500 catastrophic events and 34 300 buildings damaged between 1985 and 1995, as well as adverse impacts on roads and aquatic ecosystems [12]. The main areas affected by erosion are the Northwest, through intensive agriculture; and the Rhone valley and the Southwest, where vineyards and spring crops cover large areas [13, 14]. In the Northwest, reduction of crop diversity, ploughing up of grasslands, and an increase in soils left bare over winter, have caused increased erosion and associated problems such as muddy flows, turbid drinking water, and more frequent flooding through soil sediment filling water channels [7, 15, 16]. In other regions, erosion is aggravated by high rainfall and steep slopes, or by urbanisation and road construction [15, 16].

Water pollution from agriculture remains important. Pollution from industry and households has largely stabilised [7, 15, 17]. Agriculture contributes almost 75% of nitrate and 22% of phosphorus loadings into surface water. Farming is also a major source of groundwater pollution [9], and pesticide contamination of water bodies is widespread. Water pollution is especially important in the North and West [9]. In Brittany, for example, by 2006 less than 1% of inhabitants received water in excess of European Nitrate Standards part of the time. This pollution is associated with high animal stocking densities and intensive use of fertilisers [18]. In 2003, 8-9% of the population were supplied water whose content exceeded the pesticide standard at least once. For coastal waters (the English Channel – La Manche – the North Sea and Brittany) farming is the main cause of eutrophication and detection of pesticides is common [7]. Agriculture's share of the water pollution tax was only 4% in 1998 [17]. Over 1997-2002 farmers paid 1% of water pollution and withdrawal charges to Water Agencies, while receiving 10% of the Agencies' investment aid [15].

Declining agricultural nutrient surpluses are reducing the pressure on water quality. Nutrient surpluses have declined over the period 1990 to 2004, notably for phosphorus, and are below the OECD and EU15 averages expressed in terms of surplus nutrient intensity per hectare of agricultural land (Figures 3.8.2 and 3.8.4). But while France adopted the EU *Nitrates Directive* in 1993, given the lack of progress in reducing agricultural water pollution the area of *Nitrate Vulnerable Zones* (NVZs) was extended in 1999. In 2002, in response to a ruling by the European Court of Justice that France had contravened the Directive, the area of NVZs were further expanded, especially to control eutrophication of La Manche (the Channel) and the North Sea, but by 2007 the NVZ area was expected to be stable [15]. Two-thirds of the nitrogen discharged into La Manche from the River Seine is of agricultural origin [15].

While overall there has been a downward trend in pesticide use, water contamination appears to be widespread and is a cause of concern. Since 1990 although there was a significant annual fluctuation in pesticide use (Figure 3.8.3), the frequency of application, expressed as the average number of approved doses applied annually per hectare of cropland, between 1993-94 and 2000-01 increased by 10%, although information for other crop years is required to determine a long term trend. In 2002 80% of surface water and 57% of groundwater samples contained pesticides; 40% of surface water and 21% of groundwater had levels requiring decontamination for drinking purposes; and almost 7% of water contained a level of pesticides excluding its use for drinking purposes [17, 19]. Between 1996 and 2000, highly persistent pesticides, such as DDT, lindane, and their derivates, were found in many monitoring points along the coast, despite the ban on their use being in place for several decades [7, 19].

Agriculture's use of water has risen, heightening competition between different water users in some regions (Figures 3.8.2 and 3.8.4). The area of irrigated land increased by around 480 000 hectares between 1990-92 and 2001-03, from 5% to 9% of the total agricultural area. This was due to changing cropping patterns, especially the switch from horticultural crops to maize, soya beans and sunflowers, linked to CAP support raising incentives to use irrigation water [10, 20]. Farming accounts for about 14% of total water use (2001-03), with its share in groundwater use increasing from around 10% in the mid-1980s to 17% by the mid-1990s, compared to stable national usage [21]. In some water scarce regions, where agriculture's share of total water use is higher, there are growing conflicts for access to water resources between different users (farmers, urban, industrial); and over the maintenance of water flows for aquatic ecosystems [22].

Agricultural ammonia emissions have remained virtually unchanged since 1990. Ammonia emissions from agriculture, which account for 97% of total ammonia emissions, decreased by 0.3% between 1990-92 and 2001-03 (Figures 3.8.2 and 3.8.3). Total ammonia emissions by 2001-03 (768 000 tonnes) were below the 2010 target (780 000 tonnes) agreed by France under the *Gothenburg Protocol*, being one of only a few EU15 countries to meet its Gothenburg target at this stage. France has now stopped use of the fungicide ***methyl bromide*** in the primary agriculture sector, but it is still used in treating timber.

Agriculture is contributing to lowering national greenhouse gas (GHG) emissions. Farming contributes 17% (2002-04) of total GHG emissions, but there has been an 8% reduction over the period 1990-92 to 2002-04 (Figure 3.8.2), compared to stability of emissions in the rest of the economy [23]. Agriculture contributes to ***carbon storage***, and together with forestry, the soil carbon pool is the equivalent of 5% of total GHG emissions [24], thus helping to reduce GHG abatement costs [25]. Over the 1990s the capacity of agricultural soils to store carbon may have declined [5]. The expansion in agricultural biomass production for ***renewable energy*** can also help to lower GHG emissions. While this source of energy is growing rapidly its share in total energy consumption, however, remains less than 1%, and in transport fuel consumption less than 2% [15, 26, 27, 28]. Meanwhile, agricultural energy efficiency is improving, with a slight rise in the volume of farm production over the period 1990-92 to 2002-04 compared to a 9% decline in direct on-farm energy consumption (Figure 3.8.2).

Agricultural land use changes have had a mixed impact on biodiversity and landscapes. Agriculture occupies nearly 55% of the total land area, although the area farmed declined by nearly 3% between 1990-92 and 2002-04 (Figure 3.8.2). Substantial areas of farmland are classified by the Ministry of the Environment as areas of special importance for wildlife (ZNIEFF areas), with 24% classified as having a very "high nature" value and 36% classified as having "considerable biodiversity potential" [7, 15]. Although the overall impact, either positive or negative, is unclear, key changes in farmland use from a biodiversity perspective since 1990, have included the net conversion of farmland to forest and the conversion of wetlands to cropland. Almost 3 000 hectares of wetlands was converted annually to agricultural use between 2000-03, and there was a fourfold increase in the fallow area to over a million hectares by 2003 [29]. The area of farm hedges have increased from 360 000 to 610 000 hectares between 1990 and 2002 [29], partly because 15-20% of national hedges (in linear terms) are covered under hedge restoration schemes [3].

Agricultural activities are a pressure on the conservation of certain wild species. Farmland ecosystems contain the largest number of France's endangered species [15], and between 1989 and 2003 national bird populations declined by 3%, compared to a 25% reduction for birds using farmed habitats, although populations recovered slightly in 2004 and 2005 (Figure 3.8.3) [5, 15]. In 2000 the European Court of Justice found France had not properly implemented the EU *Bird Directive*, its network of *Special Protection Areas* for birds being the smallest share of the national land area in the EU15 [15]. Amphibians, reptiles and invertebrates, including bees, have been adversely affected by farm intensification such as the removal of small habitats [5, 30] and the use of farm chemicals, including eutrophication of aquatic habitats [15]. Biodiversity and landscapes may have also been adversely affected by the net conversion of pasture to arable land (Figure 3.8.3) [31], especially since 1992, and the switch to area based farm payments [32].

Overall, according to the Ministry of Agriculture, the diversity of farmed landscapes has been greatly reduced. This has largely been due to the standardisation of farming practices; rationalisation of production systems; and enlargement of field sizes; while there has been encroachment on farming landscapes from urbanisation. Recent evidence suggests, however, that the heterogeneity of farmed landscapes might be increasing [33], although livestock herding and pasture areas in mountain regions have declined to the detriment of landscapes and biodiversity [7], despite support programmes to maintain these areas [15, 34].

3.8.3. Overall agri-environmental performance

Overall agri-environmental performance has been mixed. While agricultural activities are a key source of water pollution, decreasing levels of nutrient surpluses and pesticides are lowering pressure on the environment. But in the north and west regions, where the intensity of farming is high and production has risen, problems of soil erosion and water and air pollution are acute. Irrigated farming, that in the past was concentrated in Mediterranean regions, is now well developed in the south-west, central and Rhone Valley regions, increasing pressure on water resources which can damage aquatic ecosystems. The overall intensity of farming practices and land use changes are damaging biodiversity, with reductions in farm bird populations and loss of grasslands to arable crops. However, the efficiency of purchased input use has improved, with an increase in the volume of farm production at the same time as a reduction in fertiliser, pesticide and energy use [5, 15]. In addition, agricultural greenhouse gas emissions have been lowered, and renewable energy produced from agricultural biomass expanded.

Agri-environmental monitoring and evaluation is being strengthened [15, 35]. Monitoring of nutrients and pesticides in water bodies is well developed, although agricultural pollution from endocrine disrupters, antibiotics and pathogens are poorly understood [15]. An indicator of pesticide use pressure has been established under the 2006-09 *Interministerial Plan for the Reduction of Pesticide Risks*. Agricultural land use information is being further improved [36, 37]. Data on trends in agricultural water use are limited, but, since 2000, irrigators without a water meter and withdrawal licence no longer receive CAP support [15]. Monitoring of soil erosion [12], soil organic stocks, biodiversity and farmed cultural landscapes need strengthening, while estimates of the environmental costs of agricultural water pollution would be informative for policy makers [17].

Recent policy changes may improve performance. By the end of 2003 nearly 40% of farmers and 28% of agricultural land were included under agri-environmental measures [3]. Provisions under EU *Agenda 2000* and the *2003 CAP reforms* will involve, from 2005/06, the use of cross compliance targeted at farming practices intended to benefit the environment, such as: maintaining grass strips; not burning straw and crop residues; using rotations; monitoring irrigation water; and enforcing a set of statutory minimum agri-environmental practices [3, 30, 31]. From 2003 a new regulation on natural risks delineates areas of erosion risk, where farmers and land owners are obliged to apply soil protection measures against erosion [12].

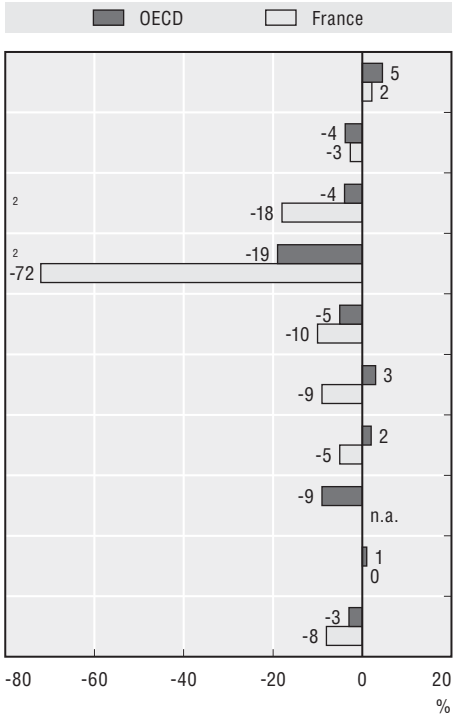
In terms of reducing water pollution, payments to farmers are now conditional on respecting the EU Nitrates Directive, with improved fertiliser management practices already observed and likely to further reduce nutrient surpluses. From 2007 with the end of the programme on containing agricultural pollution, support from Water Agencies to farmers will be redirected to support for environmentally beneficial practices instead of support for investments. Starting in 2008, a new tax system will be applied to nitrogen and

phytosanitary products leading to an increase in the number of livestock farms taxed. The adoption of a *National Biodiversity Strategy* in 2004, which includes agriculture, could help toward improved conservation. A *biofuel production scheme* from 2005 aims to raise the share of biofuels in transport fuels to nearly 6% by 2010, through production support and fuel tax reductions. Biomass and animal waste used for energy generation already benefit from higher tariffs into the national grid [26].

But many environmental issues still need attention. To comply with the EU *Water Framework Directive* further effort will be required to curb agricultural ***nutrient pollution*** [3, 15, 17]. Agricultural water pollution is imposing a cost on society in terms of treating drinking water supplies to meet nutrient and pesticide standards; and also causing harm to aquatic ecosystems. ***Subsidised water*** pricing for irrigation does not provide incentives to conserve water resources. ***Adverse impacts on biodiversity*** have been partly reduced through agri-environmental measures in grassland and mixed farming regions [3], but more effort will be required if France is to improve its performance under the EU's *Bird and Habitat Directives* and reduce threats to habitats and wild species [15]. Agriculture has succeeded in ***reducing GHG emissions and energy use***, and increased renewable energy production, but concessions on fuel used by farmers provide a disincentive to improve energy efficiency, and help further reduce greenhouse gas emissions.

Figure 3.8.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

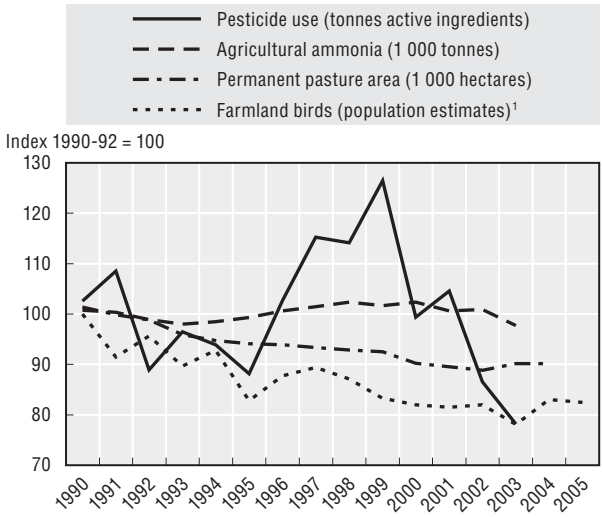
Variable	Unit		France	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	102	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–809	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	54	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	4	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–9 750	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–297	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–225	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	n.a.	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–2	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–8 169	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

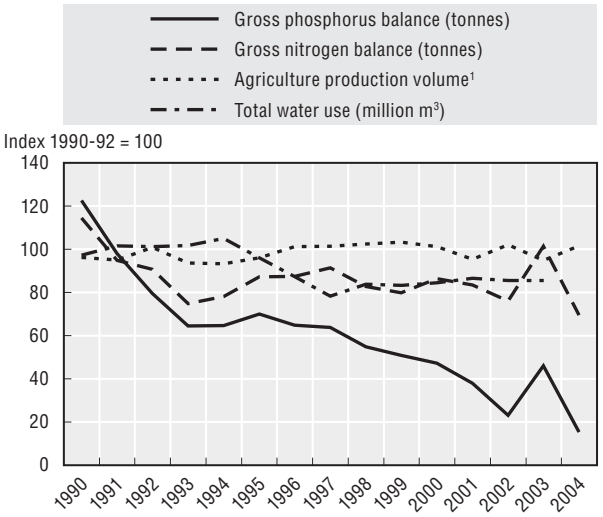
Figure 3.8.3. **Trends in key agri-environmental indicators**



1. Index 1990 = 100.

Source: OECD Secretariat.

Figure 3.8.4. **Trends in key agri-environmental indicators**



1. Index 1999-2001 = 100.

Source: OECD Secretariat.

StatLink http://dx.doi.org/10.1787/300136632603

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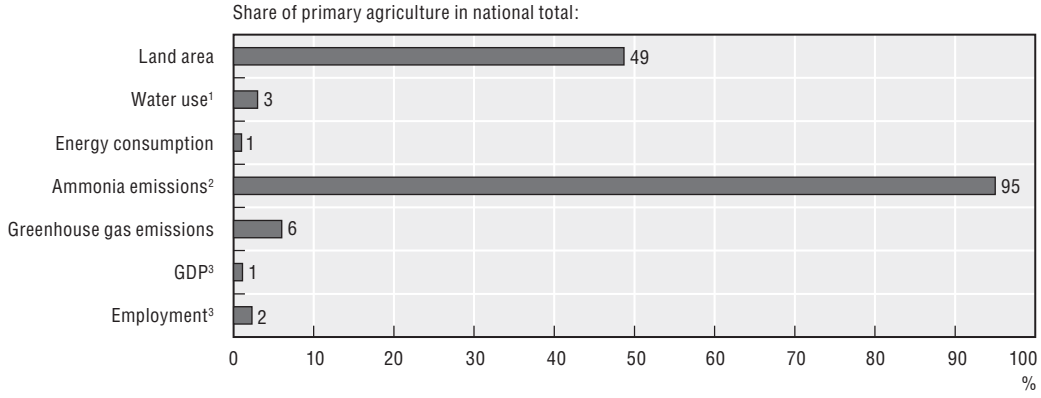
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3.9. GERMANY

Figure 3.9.1. **National agri-environmental and economic profile, 2002-04: Germany**



StatLink http://dx.doi.org/10.1787/300157315708

1. Data refer to the year 2001.
2. Data refer to the period 2001-03.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.9.1. Agricultural sector trends and policy context

Agriculture plays only a minor role in the German economy. The sector currently contributes about 1.1% to GDP and 2.3% to employment (Figure 3.9.1). Overall the volume of farm production declined slightly over the period 1990-92 to 2002-04, with lower livestock production (–6%) but increasing crop output (+13%). The intensity of agricultural production appears to be diminishing with farm input use declining more rapidly than production. There has been a decrease over the period 1990-92 to 2002-04 in the use of inorganic nitrogen (–6%) and phosphate fertilisers (–49%), pesticides (–11%) and direct on-farm energy consumption (–20%) (Figure 3.9.2).

Since German reunification in 1990, changes in the farming sectors of the Old Länder (former West Germany) and the New Länder (former East Germany) have significantly differed. In the New Länder farming contracted sharply following unification, with farm employment falling to 20% of its 1989 level by the early 1990s [1]. Old Länder farming is dominated by livestock, raising over 75% of the nation's cattle, sheep and pigs. Farm size in the Old Länder is about 30 hectares compared to 200 hectares on average in the New Länder. By contrast in the New Länder crops dominate and farming is more capital intensive [2].

Agriculture is mainly supported under the Common Agricultural Policy (CAP), with support also provided through national expenditure within the CAP framework. Support to EU farmers has declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate). This compares to the OECD average

of 30%. Nearly 70% of EU farm support under the Agenda 2000 was output and input linked, falling from over 98% in the mid-1980s [3]. Budgetary support to German farmers is currently EUR 8 billion per annum of which about EUR 5 billion per annum is funded by the Länder. Around a quarter of budgetary expenditure is for less-favoured areas and agri-environmental measures [3, 4].

Expenditure on agri-environmental programmes in Germany has risen substantially and is largely administered at the Länder level. The spending on agri-environmental measures is mainly aimed at providing payments to farmers for environmentally beneficial farming practices, such as: reducing water pollution; enhancing biodiversity conservation; and promoting organic farming [5, 6]. There are also regulatory measures that enforce certain environmental friendly farming practices including those concerning fertiliser application and livestock densities [7, 8], while the 1998 *Federal Soil Protection Act* requires farmers to adopt soil conservation practices [9]. Organic farming accounted for 4.7% of farmland in 2005 (Figure 3.9.3) [2, 10]. To encourage organic farming, under the *Federal Organic Farming Scheme* EUR 16 million was provided in 2007 and EUR 10 million per annum will be provided from 2008 until 2010 [3].

Agriculture is affected by a number of economy-wide environmental and taxation measures, and international environmental agreements. Farmland in nature conservation areas is exempt from property tax [1]. Farmers were also provided an 80% exemption on the standard rate of tax on fuels, equivalent to EUR 420 million of budget revenue forgone in 2006 [1, 3, 11, 12]; although this exemption was reduced to 40% in 2005 [11]. From 2003 a reduced electricity tax rate was also provided to farmers of EUR 12.30/Megawatt hour (MWh). This compares with the full rate of EUR 20.50/MWh for other users [13]. Under the *Renewable Energy Act*, electricity grid operators are obliged to purchase electricity using a differentiated feed-in tariff. Biofuels have tax exemptions and support is provided for the construction of biomass installations for heat production. An Action Plan to reduce ammonia emissions from agriculture was launched in 2003, aiming to lower ammonia emissions relative to 1990 levels by about 25% by 2010 [3]. Farming is also affected by commitments under ***international environmental agreements***, in particular, the reduction of nitrate pollution into the Northeast Atlantic (*OSPAR Convention*) and the Baltic Sea (*HELCOM Convention*), and ammonia emissions under the *Gothenburg Protocol* [1, 14]. A federal ammonia reduction programme was established in 2003 including several measures exceeding substantially requirements of the both the EU and the Gothenburg Protocol.

3.9.2. Environmental performance of agriculture

Two key environmental concerns related to farming include water pollution, especially for areas where there is intensive livestock production, and the interaction of farming with biodiversity. Other environmental issues of importance to agriculture include ammonia and greenhouse gas emissions, soil erosion and land use. Increased attention is being paid to developing agriculture's potential to supply biomass feedstock for renewable energy production.

Agriculture as the major land using activity accounts for around 50% of land use. Despite near zero population growth, pressure on land resources is intense. This is largely because of high population density and also because demand for environmental conservation, as expressed through public opinion surveys, remains high, especially for biodiversity and landscape [1]. A downturn in the economy, however, has seen a decrease in public priority given to environmental issues compared to the early 1990s [1]. Agricultural use of national

water resources is small, a share of about 3% (2001-03), reflecting the minor role of irrigated agriculture, the abandonment of irrigation facilitates in the New Länder following reunification, and underlying climatic conditions. However, agriculture has been adversely impacted by the growing incidence and severity of floods over the 1990s [1].

Soil erosion and compaction are a problem in some regions, but overall soil quality is in good condition. Soil erosion rates reveal considerable differences between regions. [9]. The extent of the problem concerning soil compaction is not clear due to the lack of coherent monitoring [15, 16].

Pollution of water from agriculture declined over the 1990s, but remains a concern. With marked reductions in both agricultural nutrient surpluses and improper pesticide use, the pressure from agriculture on water pollution has been reduced. But as point sources of water pollution (*i.e.* industrial and urban sources) have been drastically reduced over the 1990s [17, 18], agriculture accounts for a growing share but lower absolute quantity of water pollution, estimated at nearly 60% of nitrogen and 50% of phosphorus discharges in surface water [1, 2]. While reductions of nutrient surpluses have been significant, the decrease in nutrient loadings into the Baltic and Northern Atlantic has been smaller [1, 18, 19]. This reflects the time lags between the physical reductions in soil nutrient loadings and the effects showing up in lower discharges in water bodies, which are particularly pronounced for phosphorous [1, 19].

The reduction in agricultural nutrient surpluses over the period 1990-92 to 2002-04 was amongst the largest in the EU15. The closure of many livestock operations in the New Länder following reunification and greater efficiency in the use of inorganic fertilisers (*i.e.* crop production rose by 13% compared to a 6 % reduction in inorganic nitrogen fertiliser use and 49% for phosphate fertiliser over the period 1990-92 to 2002-04), has led to a significant reduction in nutrient surpluses. Nationally, however, average absolute levels of nitrogen surpluses per hectare remain appreciably above the OECD and EU15 averages, but not for phosphorus, although there is considerable regional variation in nutrient surpluses (Figure 3.9.2). For areas where livestock are concentrated (mainly in the North West and South East) nitrogen surpluses are more than double the national average [20].

Reduction of pesticide use has lowered the risk of water pollution (Figure 3.9.2). Although, certain active substances have been regulated since the 1990s, they are still found above the limit stipulated by the *Drinking Water Ordinance* of 0.1 μg/l in water bodies, but with a decreasing trend. Pesticide risk indicators show that over the 1990s the risk to the environment (mainly fauna and algae) from herbicide use has declined, while for some fungicides and insecticides the risks have increased [1]. Farmers appear to have improved their efficiency of pesticide use as the volume of crop output rose by 10% while pesticide use fell by 11% over the 1990s.

Air pollution from farming activities showed a significant reduction over the period 1990 to 2004. Agricultural ***ammonia emissions*** decreased by 10% from 1990-92 to 2001-03, largely because of a decline in livestock numbers, with agriculture contributing about 95% of national total ammonia emissions. Germany has agreed to cut total ammonia emissions to 550 000 tonnes by 2010 under the *Gothenburg Protocol* and by 2001-03 emissions totalled 608 000 tonnes, so a further 11% cut will be required to meet the target.

Agricultural greenhouse gas (GHG) emissions fell by 11% over the period 1990-92 to 2002-04, largely due to the decrease in livestock numbers, fertiliser use, and energy use (Figure 3.9.2) [21]. But the decrease in national total GHGs was greater at 14%, while the

German target for total emissions under the EU *Burden Sharing Agreement* towards the 2008-12 *Kyoto Protocol* is a 21% reduction. To some extent agricultural GHG emissions are offset by agricultural soils being a major sink for carbon, with an estimated 7 billion tons stored in the first 30 cm of soil [2]. Support through the *Renewable Energy Act* is encouraging a rapid expansion of agricultural biomass as a feedstock to produce biofuels and generate heat and electricity (Figure 3.9.4). The current contribution to total fuel and electricity supplies is under 1%; and nearly 4% for heating [22, 23].

Agricultural use of chemicals and land use changes have harmed wild species and habitats, but conservation of farm genetic resources led to some improvement. A major cause of decline in wild plant species has been attributed to farming, although recently the loss of plant species has slowed [1, 24]. Fauna, especially birds, show a similar trend with farming seen as a major threat to 40% of "Important Bird Areas" [21]. Grassland habitats are important to some flora and fauna, and efforts are underway to conserve them, for example extensive grassland [1, 24, 25]. But the area of permanent pasture declined by –8% over the period 1990-92 to 2002-04 with some of this land converted to crop use, although since 2005 measures have been introduced to limit such conversion. Erosion of agricultural genetic resource diversity for both crops and livestock has remained constant or improved slightly over the past decade. Increasing policy efforts are targeted to safeguard genetic resources [1, 26, 27].

Concerns for landscape conservation and flood control management are related to the decline of the area farmed. The agricultural land area declined by about 2% from 1990-92 to 2002-04 (in 2002 about 105 hectares/day was converted from agricultural to other land uses). At the same time, there is evidence of public demand for protecting cultural heritage in some agricultural landscapes, such as conservation of hedgerows [28], but the extent and trends in agriculture's impact on landscapes is unknown [29]. The Federal Government is seeking to reduce the rate of conversion of agricultural and forest land to other uses [1].

3.9.3. Overall agri-environmental performance

Overall pressure on the environment from agricultural activities has declined since 1990. Much of this improvement is due to the marked reduction in purchased farm input use relative to the volume of agricultural production, especially crop production, which rose since 1990 because of the adoption of improved varieties and farming methods. Also, the contraction of the farm sector in the New Länder following reunification has reduced pressure on the environment. Despite these improvements the absolute levels of agricultural water pollutants remains high and national (*e.g.* EU *Nitrates Directive*) and international targets (*e.g. OSPAR and HELCOM Conventions*) have not been met to their full extent, which also applies to ammonia emissions in terms of meeting the *Gothenburg Protocol* targets. In addition, adverse impacts from agriculture on biodiversity persist, although some improvement is evident in the conservation of agricultural genetic resources.

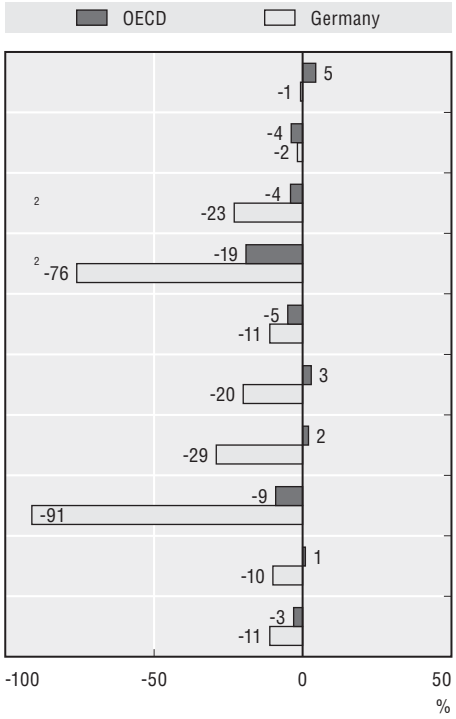
Monitoring and evaluation of agri-environmental trends has been strengthened. Where Germany has reporting obligations under international environmental agreements, such as the *OSPAR and HELCOM Conventions*, data availability are satisfactory. However, information on the impacts of agriculture on soil erosion, biodiversity, landscapes and flood management control is weak, and there is no legal requirement to collect pesticide use data, which are only estimates [30].

Recent strengthening of agri-environmental policies may lead to further improvements in agri-environmental performance. New provisions under Agenda 2000 and the 2003 CAP reforms, however, are expected to contribute to reducing environmentally adverse impacts as they reduce support linked to production, and strengthen the use of cross compliance. This is reinforced by a range of environmental measures at the Länder level and by targets over the next decade, such as reducing water pollution [1]. These measures have encouraged application of sustainable farming practices which are now applied on nearly 30% of the total agricultural area (among the highest share in the EU15) [31]; and reduced land use intensity and production per hectare compared to farms not adopting these practices [6]. The uptake of agri-environmental programmes, however, tends to be lowest in regions with high intensity farming [7, 31].

Water pollution and biodiversity remain key agri-environmental challenges. Despite a significant reduction of water pollution caused by agricultural activities, agriculture accounts for the major and rising share of nitrogen and phosphorus discharges into water bodies, mainly because pollution from non-agricultural sources has been declining more rapidly than for farming. Water pollution from pesticides and heavy metals derived from fertilisers persists, although the risk of pesticide pollution of water bodies has declined. Certain farm chemical use practices and land use changes continue to impact adversely on biodiversity, and agricultural land use changes are also raising concerns regarding landscape conservation and flood management control in some regions. Concessionary fuel and electricity taxes for farmers can act as a disincentive to more efficient energy use, and to limiting greenhouse gas emissions.

Figure 3.9.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

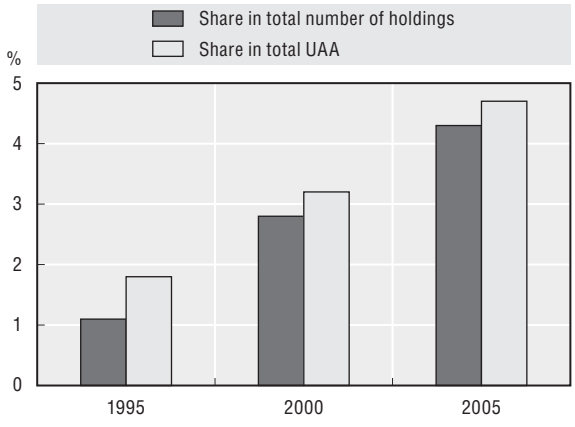
Variable	Unit		Germany	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	99	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–292	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	113	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	4	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–3 646	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–686	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–460	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	0.3	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–66	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–8 066	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

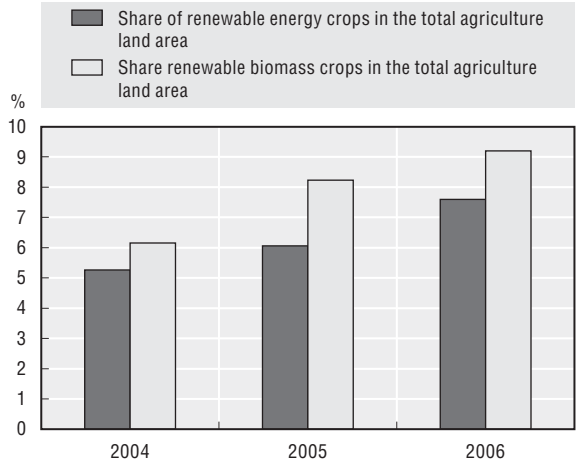
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.9.3. **Share of the number of farms and Utilised Agricultural Area (UAA) under organic farming**



Source: Federal Ministry of Food, Agriculture and Consumer Protection.

Figure 3.9.4. **Share of renewable biomass and energy crop area in the total agricultural land area**



Source: Federal Ministry of Food, Agriculture and Consumer Protection.

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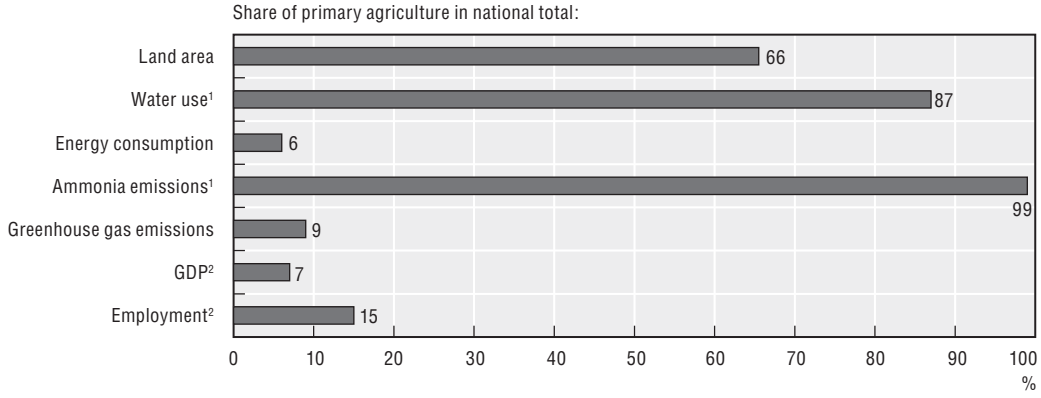
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3.10. GREECE

Figure 3.10.1. **National agri-environmental and economic profile, 2002-04: Greece**



StatLink http://dx.doi.org/10.1787/300287152126

1. Data refer to the period 2001.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.10.1. Agricultural sector trends and policy context

Agriculture continues to occupy an important position in the economy, but its contribution is declining. Between the early 1990s and 2004 the share of agriculture in GDP declined from 14% to 7% and the share of farm employment in total employment from 22% to 15% [1, 2]. Farming accounted for two-thirds of total land use and nearly 90% of water use in 2001-03 (Figure 3.10.1).

While the overall volume of farm production changed little between 1990-92 and 2002-04, the volume of crop production rose by 2.6% but livestock production declined by 2.1% (Figure 3.10.2). Moreover, the intensity of production increased and agricultural productivity improved [3, 4]. The rise in crop production was mainly accounted for by higher output of notably olives, vines for wine, cotton and some horticultural crops, as overall livestock production declined, although poultry, sheep and goat numbers rose [1]. There was a 2% decrease in the area farmed between 1990-2 and 2002-04 but the use of inputs increased during this period including for pesticides (39%), water (33%) and energy (10%), but inorganic fertiliser use (nitrogen and phosphorus) decreased by around –40%. Small family plots of less than 5 hectares, compared to the EU15 average of over 16 hectares, account for three quarters of farmland, and around 60% of farms are situated on hilly or mountainous terrain [5].

Farming is mainly supported under the Common Agricultural Policy (CAP) with support also provided through national expenditure within the CAP framework. Support to EU farmers on average declined from 41% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate – PSE) compared to the 31% OECD average. Nearly 70% of EU support to farmers was output and input linked in 2002-04

(compared to over 90% in the mid-1980s), the forms of support that most encourage production [6]. Total budgetary support to Greek agriculture was EUR 3.5 (USD 4.4) billion in 2004, of which 12% (EUR 406-USD 508 million) was financed out of the national budget. Agri-environmental measures accounted for almost 2% of total budgetary support [6].

Agri-environmental policies focus on promoting organic farming and reducing water pollution [7]. Under the *Rural Development Plan* 2000-06 (RDP): more than 50% of agri-environmental expenditure is allocated to promote organic farming; nearly 40% to the reduction of nitrate pollution of agricultural origin, especially groundwater; and much of the remaining 10% is used for biodiversity conservation, including programmes for the conservation of native crop varieties and livestock breeds [1, 7]. The *Organic Farming Scheme*, implemented in 1995, provides area payments to cover conversion costs and any possible income loss [8]. Under the EU *Nitrate Directive* (91/676/EEC) seven nitrate vulnerable zones have been designated by the government and farmers are required to undertake obligatory actions to reduce farm nitrogen run-off in these areas [9]. Agri-environmental measures include 20 year set-aside and afforestation of farmland. The government has encouraged the adoption of codes of good practice (*e.g.* Integrated Pest Management), with farmers receiving compensation for income losses associated with the implementation of agri-environmental programmes. Small farms in mountainous regions are eligible to a scheme that provides payments for innovative and environmentally sound investments aimed at environmental protection, lowering production costs and improving product quality [7, 9]. There is also a policy strategy to develop agriculture on the Greek islands, with emphasis on promoting organic production and the conservation of biodiversity and cultural landscapes [10].

National and regional environmental and taxation policies have implications for agriculture. The National Strategy for the Abatement of Desertification has as a target the abatement of ***desertification*** of 35% of land directly affected by desertification, and the prevention of desertification risks on 60% of the total land area by 2015 [11]. The construction, operation and maintenance costs of large and medium sized ***irrigation*** infrastructures are financed by the government with smaller farm level irrigation projects funded privately [12, 13]. Overall the price of water delivered to farmers is subsidised, with no charge for irrigation water supplied from large government irrigation facilities, while farmers pay only a minimal fee for water supplied by smaller municipal irrigation systems [9, 12, 13]. The water charges to farmers, however, vary greatly between different catchment areas and even within the catchment, depending on the water management agency [12, 13]. Access for farmers to artesian wells is commonly unlicensed [14]. Farmers are exempt from the value added tax on ***diesel fuel*** for tractors and farm machinery, equivalent to EUR 52 (USD 58) million annually of tax revenue forgone over the period 2001-05 [6], and also benefit from reduced rates on electricity prices [12]. A number of policies introduced in 2005-06 seek to encourage production and domestic consumption of ***bioenergy***, some of which will use agricultural biomass and by-products as a feedstock [15]. Measures include support of 40% of the capital costs for biodiesel plants, tax reductions for biodiesel and favourable feed-in-tariffs for generation of renewable electricity production [1, 15].

International and regional environmental agreements are important to agriculture and include those seeking to: lower ammonia emissions (*Gothenburg Protocol*), methyl bromide use (*Montreal Protocol*), and greenhouse gas emissions (*Kyoto Protocol*); address desertification and soil erosion concerns (*UN Convention to Combat Desertification*) and also biodiversity conservation (*Convention on Biological Diversity*) [10]. Greece has engaged in environmental

co-operation, at varying levels of collaboration, with neighbouring countries (Albania, Bulgaria, the former Yugoslav Republic of Macedonia and Turkey), especially concerning transboundary rivers which are of great importance to irrigation in Northern Greece [12].

3.10.2. Environmental performance of agriculture

The key environmental issues related to agriculture concern soil erosion, water quality and water resource use. Also of importance are agricultural emissions of ammonia and greenhouse gases and conservation of biodiversity and cultural landscapes. More than 80% of the country is rocky and mountainous terrain with low marginal productivity for agriculture, covered mainly by pasture suitable only for sheep and goats [5]. Many of the environmental problems facing agriculture stem from, on the one hand, the abandonment and change in use of agriculturally marginal mountainous areas (but which are often rich in biodiversity and cultural features) and, on the other hand, the intensification of farms at low altitudes exacerbating water pollution problems and competition for scarce water resources with other users [5].

Soil erosion is a major concern, especially in mountainous areas and across the islands. While there is no regular monitoring of soil erosion on agricultural soils, estimates for all land show that about 20% is subject to high risk of soil erosion, although the majority of land falls within the low to moderate category for actual erosion [16]. Most soil erosion is caused by water, but the Aegean islands are subject to both wind and water erosion [17]. Soil degradation is aggravated by a combination of unfavourable natural conditions including: the high proportion of steeply sloping farmland, heavy rainfall interspersed by long droughts, a thin topsoil layer in mountain areas; and the semi-arid climate in some parts of the country [10, 13, 18]. Soil erosion on farmland, especially in mountainous areas and the Aegean islands, has also has been attributed to poor farm management practices, including overgrazing (especially of sheep and goats), deforestation, and structural changes in agriculture, notably the abandonment of farmland [10, 18].

Agriculture plays an important role in the degradation of water bodies in some regions [5, 9]. Overall while agricultural production has intensified in some locations resulting in greater pressure on water quality the increase in production intensity was lower than many other EU15 countries over the past 15 years [4, 5, 12]. Some nutrients and pesticides in rivers are attributed to discharges from neighbouring countries [17]. Monitoring farm pollutants in water bodies is neither regular nor widespread. Pressure on water quality has increased as a result of the greater use of pesticides since 1990 [19], but the decline in farm nutrient surpluses (nitrogen and phosphorus) has eased potential pollution pressure, although not in some of the more intensively farmed areas [12, 20]. There has also been a rise in salinity of wells in mainly coastal regions, due to the over extraction of groundwater for agricultural use leading to intrusion of sea water into coastal aquifers [5, 9, 12, 17]. Heavy metals from farm run-off and other sources are at levels in certain lakes in excess of water quality standards [9, 12].

There was a large decrease in agricultural nutrient surpluses from 1990-92 to 2002-04, among the largest reductions (especially for nitrogen) across OECD countries (surpluses are the quantity of nutrient inputs minus outputs of nutrients, nitrogen – N – and phosphorus – P). Nutrient surpluses expressed in terms of kilos per hectare of farmland were less than half of the OECD and EU15 averages in 2002-04 (Figure 3.10.2). There has also been a substantial improvement in nutrient use efficiency (the ratio of N/P output to N/P input), to levels above the OECD average in 2002-04. The decrease in nutrient surpluses is mainly due to the decline in inorganic fertiliser use of 38% for nitrogen and 41% for phosphorus. In addition, less manure

resulted from the fall in total livestock numbers, especially cattle and goats, although there was a small rise in sheep numbers. Overall nutrient uptake from crops and pasture declined slightly, but not as sharply as for nutrient inputs.

Agricultural nitrate pollution of water bodies declined but remained stable for phosphorus, from the late 1990s to 2002 [17]. Despite the decline in ***nitrates***, 10% to 20% of samples from groundwater in agricultural areas exceeded the EU drinking water standard of 50 mg/l in 2001-02 [17]. There is also evidence of continuing farm nutrient pollution in surface and coastal waters at levels harmful to aquatic ecosystems, especially of some internationally important wetlands [9, 12, 20, 21, 22]. Overall the concentrations of nitrates in groundwater were higher than for surface water [17]. While ***phosphorus*** surpluses have been on a downward trend since 1990, the average concentrations in surface water have been stable because of the long time lags for the transport of phosphorus through soils into water bodies. The average concentrations of phosphorus in surface waters in agricultural areas did not exceed drinking water standards in the late 1990s [17], but have exceeded environmental water quality standards in some areas to the detriment of aquatic ecosystems [9, 23].

Pesticides are frequently detected in many rivers and lakes [16, 19]. The rise in the volume of pesticides (active ingredients) was among the highest across OECD countries from 1991-93 to 2001-03. Rivers are generally found to be more polluted than lakes and some prohibited pesticide products (*e.g.* DDT and other organochlorine insecticides) are still being detected in water bodies due to their persistence in aquatic environments [19]. Nationally in most cases pesticides were reported in low concentrations, but in areas of high use and intensive agriculture, concentrations were more elevated [19]. Greater pesticide use is also reported to have had an adverse impact on bird populations and damage to other biodiversity, such as wetlands, although this is poorly monitored [5, 12]. Adoption of ***organic farming*** and integrated pest management practices (*e.g.* biological controls, pheromones) is slowing the rate of growth of pesticide use. However, by 2003 organic farming accounted for only 1% of total farmland (30 000 hectares), of which around 50% is organic olive groves, but the total area is projected to rise to 200 000 hectares by 2010 [1, 8].

Agricultural water use grew by over 30% between 1985 and 2001, among the highest rate of growth across OECD countries, and compares to the growth in water use for the economy as a whole of 24% (Figure 3.10.2). As a result agriculture accounted for nearly 90% of water use by 2001. Much of the growth in water use is because of a 3% increase in the area irrigated from 1990-92 to 2001-03, with 17% of farmland under irrigation and over a third of arable and permanent crop land by 2001-03. Irrigation water application rates (litres per hectare of irrigated land) also increased by 7% between 1990-92 and 2001-03, and compared to a decrease of 9% for the OECD on average (Figures 3.10.2 and 3.10.3).

The increasing use and intensity of irrigation water use is of concern since about half of the water used by irrigators is extracted from aquifers [9]. For some areas this is leading to the over extraction of groundwater for irrigation beyond rates of recharge and, in certain coastal regions (*e.g.* the Argolid plain of the Peloponnesus), the intrusion of sea water into aquifers [3, 5, 12]. In some regions (*e.g.* Crete) major water losses from irrigation systems of between 45-50% of the water delivered to crops have been reported, caused by, for example, seepage, leakage and evaporation [13]. A further concern with the rise in irrigation is that its peak demand period in the summer is similarly a period of high demand for other uses notably tourism, but also a period of seasonal water scarcity [3, 9, 10, 12, 13].

There has been an improvement in irrigation management practices, with the more efficient drip emitter systems (compared to irrigation through flooding) accounting for nearly 9% of total irrigation water use in 1991 rising to 22% by 1999 [16]. Efforts are also being made to recycle wastewater effluent for use on irrigated areas [13]. Despite the greater uptake by irrigators of more efficient water application technologies, irrigation water application rates per hectare rose (*i.e.* a declining trend of irrigation water efficiency). This might be explained not only by the high water losses from the irrigation infrastructure, but also by technical inefficiency in managing drip irrigation systems due to, for example, poor education and weak extension advisory services. Research in Crete has revealed that the technical efficiency of farmers using a drip irrigation system is low and they are not fully exploiting the water resource savings this technology can provide [24]. Moreover, farmers using their own wells had a lower level of irrigation water efficiency compared to those using a common groundwater source, probably due to differences in water charges [24].

Agricultural air pollution has been declining since 1990. Agricultural ***ammonia emissions*** decreased by 5% between 1990-92 and 2001, mainly due to the drop in livestock numbers and nitrogen fertiliser use (Figure 3.10.2). Farming accounted for almost all ammonia emissions in 2001, with livestock making up over 95% of emissions. Greece's target of a reduction of total ammonia emissions to 73 000 tonnes by 2010 under the *Gothenburg Protocol* was achieved by 2001-03. For ***methyl bromide*** (an ozone depleting substance), mainly used for soil fumigation in the horticultural sector [25], use was cut over the 1990s as agreed under the *Montreal Protocol*, which seeks to eliminate all use by 2005. But in 2005 a "*Critical Use Exemption*" (CUE) was agreed up to 136 tonnes (ozone depleting potential), or about 5% of the EU15's CUEs, which under the Protocol allows farmers more time to find substitutes.

There was a 10% decline in agricultural greenhouse gas (GHG) emissions, close to the EU15 average reduction of 7% over the period 1990-92 to 2002-04 (Figure 3.10.2). The fall in agricultural GHG emissions compares to an increase of 26% for total national GHG emissions over the same period, while Greece's target for total emissions under the EU *Burden Sharing Agreement* toward the 2008-12 *Kyoto Protocol* commitments is a 25% increase. Farming accounted for 9% of total GHG emissions in 2002-04, mostly of methane and nitrous oxide [1]. The main reasons for the steady decline in agricultural GHGs are linked to the reduced use of fertilisers and to a lesser extent lower livestock numbers [1]. Projections point to a further decrease in agricultural GHGs from 2005 to 2010, but this is expected to be a smaller reduction in GHGs relative to that achieved over the period 1990-2004. The continued downward trend in GHGs to 2010 is likely to originate from reduced fertiliser use and improved manure management, as overall livestock numbers may rise for poultry, sheep and goats, but decline for dairy cattle and pigs [1]. Changes in agriculture are also leading to greater ***carbon sequestration***. Between 1994 and 2003 about 40 000 hectares of farmland were forested, and the projected continuation of afforestation of farmland should lead to an increase of GHG removals equivalent to about 5% of current agricultural GHG emissions [1].

Direct on-farm energy consumption rose by 10% compared to an increase of 36% across the economy, over the period 1990-92 to 2002-04, leading to a rise in GHGs (Figure 3.10.2). Agriculture accounted for 6% of total energy consumption in 2002-04, and projections suggest that farm energy consumption will continue to grow up to 2010 [1]. Much of the increase in energy consumption is explained by the expansion in use and size of machinery as a substitute for labour over the past 15 years [4]. The production of ***bioenergy*** from agricultural biomass and waste product feedstocks is small but expanding [1, 14, 15], with the possibility of developing energy crops [26]. Limited quantities of biogas are also

produced from livestock manure [27]. Biodiesel production, supplied from domestically produced cottonseed oil and imported oils was under 1% of total diesel consumption in 2004, but production is being encouraged by the government as part of a drive to expand renewable energy supplies [15].

Biodiversity is under growing pressure from agriculture, although the impacts of farming on biodiversity are diverse, complex and poorly monitored [3, 5]. The increasing pressure on biodiversity is mainly due to intensification in fertile areas (*e.g.* the plain of Thessaly), such as the greater use of pesticides and diversion of water for irrigation to the detriment of wetlands. At the same time there is the loss of farmed habitats from the conversion to urban use and, in marginal farming areas, from the afforestation and abandonment of semi-natural farmed habitats. The lowering of nutrient surpluses and ammonia emissions leading to a reduction in the eutrophication and acidification of ecosystems are likely, however, to help ease the pressure on ecosystems [3].

Conservation of agricultural genetic resources is a key aim of agri-environmental programmes. The diversity of ***cereal and horticultural varieties*** used in production has increased in diversity over the period 1990 to 2002. The Greek Gene Bank is due to become larger and develop further under a special project that will involve programmes of *in situ* crop, including cultivation of 77 species and local varieties and *ex situ* collections of crop germplasm, especially conservation of endangered accessions (Figure 3.10.4) [17, 28]. For ***livestock breeds*** there was little change in the numbers of breeds used in marketed production between 1990 and 2002 except for an increase in the number of pig breeds. Conservation of local breeds is considered important, especially for sheep and goats, as they are raised under mountainous and low input production systems [29]. The number of rare breeds under *in situ* conservation programmes rose from 27 000 to 33 000 animals between 1998 and 2002, supported by *ex situ* collections of animal genetic material [29]. Despite these changes there was a small rise in the number of critical and endangered livestock breeds (mainly sheep and horses) from 17 to 18 breeds between 1990 and 2002.

Agriculture is adversely impacting on natural and semi-natural habitats [3, 12]. Greece has designated 11 wetlands of international importance under the *Ramsar Convention*, two UNESCO *World Heritage* areas and numerous reserves and protected areas rich in flora and fauna [12]. Agriculture has been one of the major causes of ***wetland degradation***, including the: adverse impacts from construction of irrigation projects and diversion of water causing changes in water flows to wetlands; excessive extraction of aquifers harming water flows to wetlands; agricultural pollutant run-off, especially the eutrophication of inland and coastal wetlands; and the expansion of the area cultivated in some areas leading to a loss of wetlands [3, 12, 30]. The impact of farming on bird populations, measured by the BirdLife International ***Important Bird Areas*** (IBAs) indicator defined as prime bird habitat, shows that around 50% of the most significant threats to Greek IBAs originates from farming [31]. This threat involves not only the intensification of production but also the loss of semi-natural farmed habitat to other uses, while the construction of irrigation projects also threatens IBAs [32].

Some semi-natural farming systems provide important cultural landscapes and ecosystem services. These semi-natural habitats, however, have been in decline due to changes in land management systems [33]. On one hand, the quality of semi-natural habitats has been degraded to the detriment of biodiversity due to the adoption of more intensive farming practices, such as greater homogeneity in cropping patterns [33] and, in

some areas, uncontrolled and highly intensive sheep and goat grazing [12]. On the other hand, the area of semi-natural extensively farmed habitats has diminished due to their abandonment to shrub or conversion to forestry [5, 29, 34]. In contrast, around 75% of the area of olive groves is considered as semi-natural habitat because of the low input of chemicals and extensive system of their cultivation.

Some cultural features in farmed landscapes have been left to deteriorate, such as stone walls and terraces in the mountain olive groves of Lesvos [33]. The extensive network of ponds, terraces and small lakes across agricultural landscapes has provided certain ecosystem services, such as: reducing soil erosion rates; and providing water holding capacity, which can help recharge aquifers and reduce the severity of flooding and landslides as well as contributing to the conservation of farm habitats and wildlife using farmland. But the deterioration and disappearance of a part of this network has lowered the water retaining capacity of agricultural land [12, 17]. This is of some concern in view of the predominance of mountainous terrain; increasing occurrence and severity of droughts, floods and associated landslides; and also the depletion of aquifers in rural areas. But the introduction of agri-environmental schemes in the Greek islands, is targeting the re-building and maintenance of structures such as stone walls and terraces.

3.10.3. Overall agri-environmental performance

Overall agriculture has exerted greater pressure on the environment since the 1990s. This is in part because of the increased use of inputs including pesticides, water and energy, although there has been a reduction in fertiliser use and agricultural air pollution emissions, while the area farmed has declined. Soil erosion remains a major problem and irrigation water application rates (litres per hectare) increased compared to a declining trend for most other OECD countries where irrigation is important. There are also concerns over the conversion to other uses (mainly forestry) and abandonment of semi-natural agricultural habitats to the detriment of the biodiversity and cultural landscape benefits associated with these farmed habitats.

The agri-environmental monitoring system needs strengthening, to help improve the quality of information for policy makers to evaluate the environmental effectiveness of agri-environmental measures [35]. More effective and regular monitoring of water quality and water quantity needs to be reinforced across the main water catchments dominated by farming [9, 19], although the Ministries of Agriculture and Environment are beginning to co-operate to improve their water monitoring networks [12]. Efforts are also being made to establish indicators that track changes in cultural features in agricultural landscapes [36, 37], and improve agri-environmental indicators more widely [38].

Greater attention by policy-makers is being paid to address agri-environmental problems [1, 3, 9]. With regard to agricultural ***nitrate pollution*** of water bodies the government increased the area of designated nitrate vulnerable zones under the EU *Nitrates Directive* in 2004 to about 1% of the total agricultural area [6]. Under the 2002 *National Strategy for Water Resources* the objective is to achieve sustainable use of ***water resources***, protection of aquatic ecosystems and attainment of high water quality standards for all water bodies by 2015 [9]. There has been some improvement in the uptake of more efficient irrigation application technologies, notably the higher adoption of drip emitter irrigation systems [17]. Success has also been achieved in meeting international

environmental agreement targets to reduce agricultural ***ammonia emissions*** (*Gothenburg Protocol*) and ***methyl bromide use*** (*Montreal Protocol*), although a few farmers continue to use methyl bromide despite the commitment to phase out use by 2005.

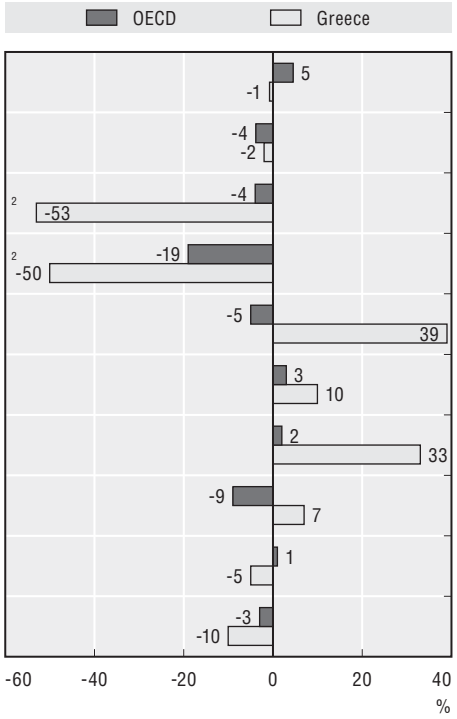
Despite policy efforts to improve environmental performance in agriculture not all problems have yet been resolved. Even though agricultural nitrate pollution of water bodies has been declining, absolute levels of pollution remain high with 10-20% of groundwater samples in agricultural areas exceeding the EU drinking water standard in 2001-02. Also pesticide use has been rising with pesticides frequently monitored in many rivers and lakes. While measures are successfully being taken to reduce water pollution from industry and sewage treatment plants, this does not appear to be the case for agricultural water pollution, experiencing poor farm management and weak enforcement of current measures to limit pollution [21]. Research suggests that there is considerable potential to raise farm output through improved efficiency in the use of inputs, which would bring environmental gains by, for example, lowering pesticide use [2]. Several of these issues are addressed by the adoption of a comprehensive set of Good Agricultural and Environmental Conditions under Cross Compliance, which is intended to further improve the environmental performance of agriculture. Fuel tax concessions and reduced electricity prices for farmers hinder the more efficient use of energy and may lead to higher GHG emissions. Increasing taxes on fuels across the rest of the economy has been shown to lead to reductions in GHG emissions [1].

Subsidised water prices and irrigation infrastructure costs deter farmers from conserving water [12]. While households and industries pay a share of the costs of the public treatment and distribution of water, this is not the case for farmers. In certain regions (*e.g.* Crete) there are reportedly major water losses from irrigation systems and increasing competition for scarce water resources between farming and tourism [3, 9, 10, 12, 13]. Moreover, despite the greater uptake by irrigators of more efficient water application technologies, irrigation water application rates per hectare rose. Research has shown that this might be explained not only by water losses from the irrigation infrastructure, but also by the technical inefficiency of farmers using drip emitter systems such that they are not fully exploiting the water resource savings this technology can provide [24]. Also farmers using their own wells had a lower level of irrigation water efficiency compared to those using a common groundwater source, probably due to differences in water charges [24].

Greece's protection of some wetlands is not very extensive or effective, including pressure from agricultural activities notably irrigation projects, with the risk that some wetlands might be removed from the international list of *Ramsar* sites [12]. In 2005 Greece was referred by the EU Commission to the European Court of Justice, as it considered Greece had not effectively counteracted the pollution and degradation of Lake Koronia an internationally important wetland [22]. The Lake has mainly been damaged through high levels of water abstraction for irrigation purposes, as well as being harmed from agricultural pollutant run-off, in addition to pollution from industry and surrounding urban areas [22]. In addition, within the framework of the EU Cohesion Fund, however, the Greek Government submitted in 2005 a new "Master Plan" that focuses on the recovery of Lake Koronia. The Plan has been approved by the EU, and a series of projects and actions (such as agri-environmental schemes and water recovery projects) will be implemented. Starting from 2006 the *Water Protection and the Sustainable Management of Water Resources* legislation enforced in December 2003, translates the 2000 EU *Water Framework Directive* into national policies. These policies hold the potential to limit water pollution, excessive water abstraction by agriculture, and protect wetlands [9, 13].

Figure 3.10.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

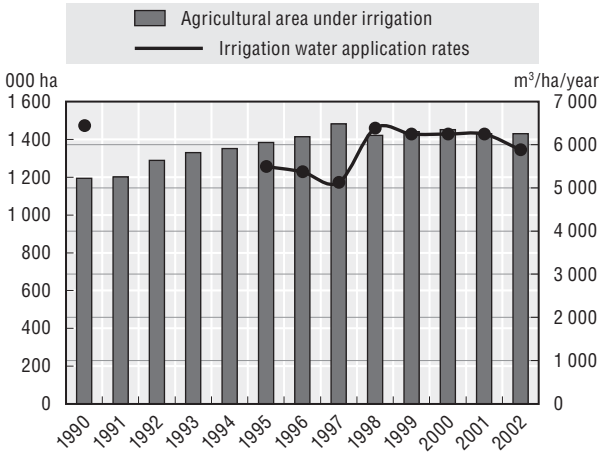
Variable	Unit		Greece	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	99	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–175	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	15	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	4	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	+3 268	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+110	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+1 906	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	5.9	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–4	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–1 304	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

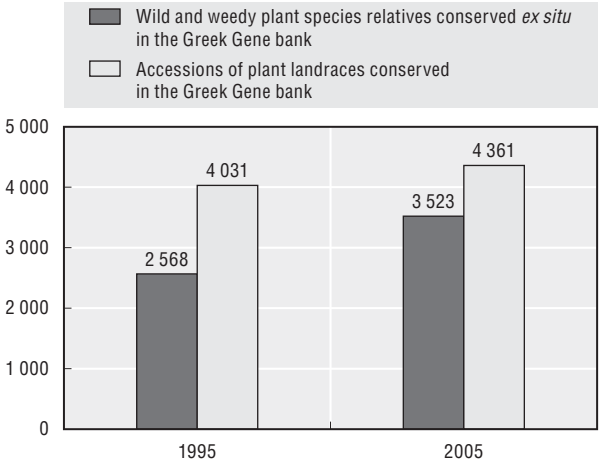
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.10.3. **Irrigated area and irrigation water application rates**



Source: Greek Ministry of Rural Development and Food.

Figure 3.10.4. ***Ex situ* accessions of plant landraces, wild and weedy relatives**



Source: Greek Ministry of Rural Development and Food.

StatLink http://dx.doi.org/10.1787/300312705330

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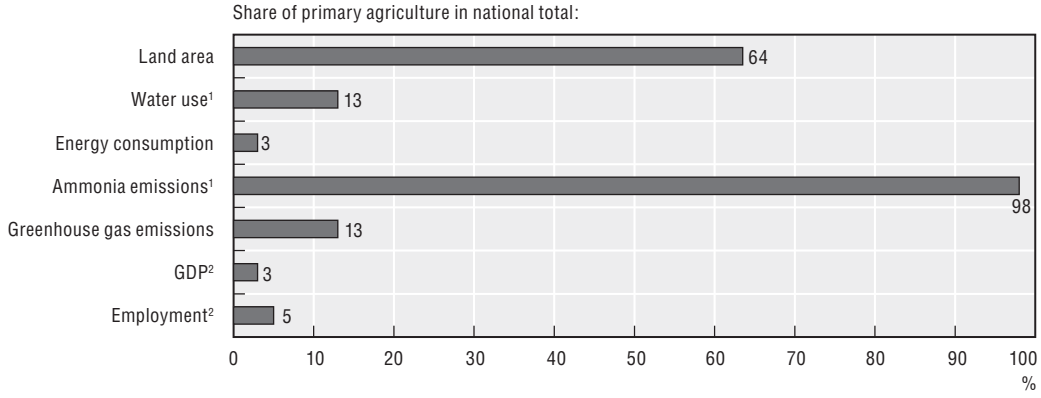
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3.11. HUNGARY

Figure 3.11.1. **National agri-environmental and economic profile, 2002-04: Hungary**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.11.1. *Agricultural sector trends and policy context*

Primary agriculture continues to play an important role in the economy, but there has been a major contraction of the sector over the period since 1990. Agriculture's share of GDP declined from nearly 14% in 1989 down to just under 3% by 2004, while over the same period farming's share of employment fell from around 17% to slightly over 5% by 2004 [1, 2, 3] (Figure 3.11.1). These changes are reflected in the –14% reduction in the volume of agricultural production (1990-92 to 2002-04), the largest decrease across OECD countries (Figure 3.11.2). Over the more recent period, from 2000 to 2005, production has increased slightly, especially for cereals, but declined for some livestock products, especially milk production [4].

The transition from a centrally planned to a market economy over the period 1990 to 2005 has had significant implications for agriculture. The fundamental change in political and social institutions as well as economic conditions, with a shift from a centrally planned to market economy, has affected how land use decisions are made, and led to extensive changes in farm ownership patterns, productivity and competitiveness [5, 6, 7, 8, 9, 10]. Overall the sharp fall in the volume of farm production during the early 1990s was induced by a major reduction in agricultural production and input support (see below), a drop in agricultural investment, and rising farm debt levels. Private family farms saw their share of the area farmed rise from around 15% in the early 1990s to over 50% by 2003-04, with a corresponding reduction in the share for large corporate farms (privatised successors of former state and co-operative farms) [11]. Research suggests that during the 1990s family farms were less productive than the remaining corporate farms, while farming remained weak in terms of international

competitiveness [8, 12]. The use of purchased farm inputs also decreased (fertilisers, pesticides, energy and water) (Figure 3.11.2), and environmental investment was curtailed, such as manure storage facilities and soil erosion mitigation [13, 14]. Although the use of farm inputs stabilised and even began to rise slightly from the late 1990s, by 2005 they still remained considerably below their peak of the late 1980s [13, 15].

Farming is supported under the Common Agricultural Policy (CAP) with support also provided through national expenditure within the CAP framework. Support to agriculture has fluctuated considerably over the past 20 years. Due to the implementation of economic reforms support declined from around 45% of farm receipts in the mid-1980s down to 12% in 1995-97 (as measured by the OECD Producer Support Estimate – PSE), but then gradually rose to 28% by 2003, as policies were geared toward EU membership in 2004. The EU15 PSE was 34% in 2002-04 compared to the 31% OECD average [5, 16, 17]. Nearly 70% of EU15 support to farmers was output and input linked in 2002-04, the forms of support that most encourage production [5]. Total annual budgetary support to Hungarian agriculture was around HUF 175 billion (EUR 660 million) for 2005 and 2006, of which around 20% was nationally financed, the remainder coming from EU funding [5]. Agri-environmental measures in Hungary accounted for about 10% of total budgetary support over this period [11].

The development of agri-environmental and environmental policy has had to address several key challenges since the early 1990s. Firstly, it has been necessary to respond to the environmental problems left from the legacy of the centrally planned economy; and secondly, policy responses have been required for EU accession and membership. In the early years of transition agri-environmental policy was not a priority, while the government lacked resources to invest in environmental protection [13, 16]. Indirectly, however, through the removal of government support for the purchase of farm inputs (*e.g.* fertilisers, pesticides, energy) and other production distorting measures, this had the effect of lowering agricultural production intensity and consequently pressure on the environment. Even so some agri-environmental policies were introduced in the early/mid 1990s, such as: limits on toxic elements in fertilisers (1992); a 50% reduction in the land tax if a farmer adopted environmentally friendly technology (1992 suspended in 1994); support of up to 40% of the costs of liming acidic soils (1997); regulations covering soil conservation under the *Land Act* (1994), including per hectare payments to limit soil erosion; and financial support to promote organic farming (1997) [16, 17].

EU accession and membership from 2004 has also brought policy challenges. The EU provided pre-accession funds for agriculture up to 2006 (including for environmental purposes) through three programmes: *SAPARD*, the most important for agriculture in terms of funding the establishment of institutions and systems of policy implementation; *PHARE*, covering institutional building; and *ISPA*, to assist infrastructure development, including environmental protection [13, 17]. The EU accession period since 2004 has required the adoption of EU agri-environmental and environmental policies, and harmonisation of technical standards [5, 13]. Policies under the CAP are being phased in up to 2013, when CAP support reaches 100% of the EU15 level. The main agri-environmental programme is the *National Rural Development Plan* (NRDP) from 2004, which incorporated the former *National Agri-environmental Programme* started in 2002 [1, 11, 15, 18, 19]. The two main agri-environmental measures under the NRDP include support for farmers applying practices beneficial for the environment (*Entry Level Scheme*), such as per hectare payments to limit soil erosion, and payments provided for conversion to organic farming (*Organic Farming Scheme*) [17]. To comply with the *EU Nitrates Directive* the 2002 *Nitrate Action*

Programme established *Nitrate Vulnerable Zones* to regulate farms in terms of fertiliser and manure application and storage practices [11].

Agriculture is affected by national environmental and taxation policies. Hungary's first *National Environmental Programme* (NEP) from 1997 to 2002, sought to reduce harmful environmental impacts, preserve natural values, and create a harmonious relationship between economic development and environmental protection [16]. Regulations were used to target soil protection and reduce water pollution, with charges levied on water abstraction and removing land from agricultural production. The 2nd NEP (2004) strengthens the 1st NEP and places greater emphasis on biodiversity and landscape conservation [11]. Under the *National Afforestation Programme* the objective is to increase the share of forested land to 27% of the total land area by 2050 (it was about 20% in 2005), of which 80% of payments for new plantings between 2001 to 2010 would be on farmland [11, 18]. Support is provided for farm fuel use through a 70% tax exemption equivalent to about EUR 80 (USD 100) million of budget revenue forgone annually during 2004 and 2005 [5]. Under the *Water Management Act* (1995), now replaced by the *EU Water Framework Directive*, farmers pay a fee for the abstraction of groundwater. Under the NRDP support of HUF 77 (USD 0.31) million in 2005 was provided for irrigation infrastructure costs [17].

International environmental agreements also have implications for agriculture, with respect to limiting emissions of: ammonia (*Gothenburg Protocol*), methyl bromide (*Montreal Protocol*) and greenhouse gases (*Kyoto Protocol*). Under the *Climate Change Operative Programme*, the objectives for agriculture are to reduce methane emissions from livestock and crop cultivation and provide support for renewable energy generation [18]. For energy crops farmers can obtain support of EUR 27 (USD 34) per hectare for wheat, maize, rapeseed and sunflowerseed, and EUR 32 (USD 40) per hectare for grasses [18]. Biodiesel is exempted from value added tax and excise duty [20]. As part of its commitments under the *Convention of Biological Diversity*, Hungary is seeking to restore wetlands and implement other measures for habitat conservation under the NRDP for agriculture [21]. In addition, there is an action plan to promote conservation of plant and livestock genetic material [21]. Through the *Carpathian Convention*, established in 2006, Hungary, together with other countries in the region, is seeking the conservation of this UNESCO Biosphere Reserve, including conservation of semi-natural farmed landscapes. Hungary also has a number of other bilateral and regional environmental co-operation agreements with neighbouring countries, notably concerning water resources, as the country is entirely within the Danube basin with 95% of its water originating in other countries [22].

3.11.2. Environmental performance of agriculture

Environmental concerns related to agriculture have changed dramatically over the period since 1990. With the reduction in agricultural production and input support, and shift to a market economy, farming moved from an intensive production orientated system to adoption of more extensive farming methods, linked particularly to the large decrease in use of purchased farm inputs. During the period before transition the primary agri-environmental problem was excessive nutrient application and associated water and air pollution, but over the 1990s the problem switched to a lack of nutrients and soil degradation [11, 16, 19]. Soil erosion persists as a key issue, partly because of the legacy of decades of damaging farming practices [11, 14]. While the pressure on biodiversity has eased with more extensive farming practices, land fragmentation and cessation of farming has been a problem in some areas [11, 14].

Soil erosion is a major and widespread environmental problem, but other soil degradation processes are a concern in some localities [11, 23]. Nearly 40% of farmland is affected by water erosion and around 25% by wind erosion, mainly in North Hungary and Transdanubia [19, 23]. The share of farmland subject to moderate to severe water erosion risk (greater than 10 t/ha/year) was around 25% over 2000-02, which has changed little since the early 1990s (Figure 3.11.3) [24]. While soil erosion risks are exacerbated by a combination of climate, steep topography and drainage conditions [23], erosion has also been aggravated by less than 1% of arable land being brought under soil conservation practices in 2000-03 [11, 19, 24]. It is possible, however, that with the increase in agro-forestry and the abandonment of farmland to permanent vegetation erosion rates could fall in some areas [14]. Although farm productivity has been impaired in areas of more severe soil erosion, off-farm problems are becoming more significant, such as sedimentation of the Lake Balaton ecosystem, and transport of nutrients into other lakes and rivers [23]. Severe ***soil acidification*** has accelerated over the past 20 years, but the area affected (13% of the total land area) has not grown significantly, partly because of the decrease in the intensity of fertiliser since the 1980s, although the annual area limed (to counteract acidification) declined from 30-40 000 hectares in the 1980s to now about 10-20 000 hectares. ***Soil salinisation*** limits soil fertility and productivity on around 15% of agricultural land [11]. Since 2000 about 50% of arable land was affected by ***soil compaction***, with about a quarter of this land suffering moderate to severe compaction, mainly from the movement of farm machinery on wet soils [11]. This problem has been accelerated in recent years because of extensive water logging followed by drought conditions, such that compaction is beginning to have an economic impact through reducing crop yields [25].

There is no significant pollution of water from agriculture, although in some locations inappropriate farming practices have led to moderate pollution risks [11]. The large reduction in phosphorus surpluses and pesticides over the 1990s has considerably eased farm pollution pressure on water bodies, although since the late 1990s use of inorganic nitrogen fertilisers and pesticides have begun to rise slightly. However, it is not possible to adequately assess the extent of water pollution from agriculture as there is no national water monitoring system for farm pollutant sources of rivers, lakes and groundwater, although projects financed by PHARE are seeking to improve the monitoring system [11, 19].

Trends in nutrient, (nitrogen – N and phosphorus – P) balances have shown great fluctuations between 1990 and 2004. In the late 1980s nutrient surpluses were at a comparable level to those of the EU15 average, although by the early 1990s the reduction in surpluses was so great that soil fertility was at risk with average national balances showing negative values. But from around the late 1990s there has been a slow increase in surpluses, although by 2004 the surpluses were still well below the averages for the OECD and EU15 (Figure 3.11.2). While the N balance has been in surplus over much of the 1990s to 2004, for much of this period the P balance has been negative (*i.e.* crop and pasture needs for P are greater than the supply of P from mainly inorganic fertilisers and P in livestock manure) [26, 27]. The reduction in support to fertilisers and crop and livestock products during the transition period explains much of the decrease in nutrient surpluses [1, 26]. This is highlighted by the fluctuations in the use of inorganic N fertilisers which fell from (figures in brackets are for P fertilisers) around 600 000 (330 000) tonnes in the late 1980s down to 150 000 (25 000) tonnes in the early 1990s, rising to about 300 000 (70 000) tonnes by 2002-04, *i.e.* half the late 1980s' level (almost one-fifth for phosphate).

Overall, with the low levels of nitrogen surpluses from agriculture, the pollution of water bodies from nitrates is generally low [19]. The rising levels of nitrogen surpluses since the late 1990s, however, have increased pressure on water quality in some areas. Within *Nitrate Vulnerable Zones* (designated under the *EU Nitrates Directive*), which accounted for around 45% of farmland between 2000-02 [11], almost 9% of groundwater monitoring points exceeded the EU nitrate drinking water standards, a situation that has deteriorated since the mid-1990s [14, 26]. Also 10% of surface water monitoring across the country exceeded the EU nitrate water standards. The nitrate pollution of groundwater is largely associated with large-scale intensive livestock operations, mainly due to a lack of manure storage facilities with, in the late 1990s, over 90% of manure waste discharged without treatment [28], and low rates of uptake of nutrient management plans or soil nutrient testing [11]. These problems are partly linked to the lack of capital, on the part of both farmers and government, to invest in manure storage and other manure treatment technologies; and also to inadequate knowledge of nutrient management practices. With the depletion of phosphate levels in soils over most of the period since the early 1990s, confirming a process of soil mining of P, although this does not pose an environmental threat to water quality it could impair crop P nutrition and yields over the long term [26, 27].

The 60% decrease in pesticide use was the highest across OECD countries from 1990-92 to 2001-03. The reduction in support to pesticides and crops during the transition period explains much of the decrease in pesticides use. Its use declined from around 35 000 tonnes (of active ingredients) in the late 1980s to below 6 000 tonnes by the mid/late 1990s, then rising to nearly 7 400 tonnes by 2001-03. Lower pesticide use can also be explained, to a limited extent, by the expansion in organic farming and adoption of integrated pest management (IPM). Even though ***organic farming*** grew rapidly over the 1990s, but by 2002-04 it accounted for only about 2% of agricultural land compared to the EU15 average of nearly 4% [11, 29, 30], while the area under IPM was less than 1% of the total arable and permanent crop area in 2003. With the sharp cut in pesticide use over the 1990s, the pressure on water quality was lowered, but the rise in use since the late 1990s has led to some concerns for water pollution [31].

Water management in agricultural areas is important due to the increasing incidence and severity of floods and droughts. Two-thirds of agricultural land (over 50% of the total land area) is endangered by flooding, and protection against flood damage has played a key role in farm management practices over many years, especially in the Tisza and lower Danube valleys [1, 19]. Some 10-15% of arable land is regularly flooded, sometimes between 2-4 months a year, although a network of drainage canals and reservoirs have been established to minimise damage [19]. As agriculture is largely rain-fed, use of irrigation is limited, accounting for 2% (2001-03) of the total farmland area. Agriculture's share in national water use was 13% in 2001-03, although agricultural water use declined by over 30% between 1990-92 and 2001-03, partly because of the nearly 40% reduction in area irrigated over this period.

There has been a sharp reduction in air pollution linked to agriculture. Agricultural ***ammonia emissions*** decreased by 34% between 1990-92 and 2001-03, among the largest reductions across OECD countries. Farming accounted for nearly all ammonia emissions in 2001-03, with the drop in emission levels mainly due to the reduction in livestock numbers and nitrogen fertiliser use. With total ammonia emissions falling to 66 000 tonnes by 2001-03, Hungary has already achieved its 2010 target of 90 000 tonnes required under the *Gothenburg Protocol*. Further reductions in ammonia emissions could be achieved if poor

manure storage and fertiliser spreading practices were improved [11]. For ***methyl bromide*** use (an ozone depleting substance) Hungary has almost eliminated its use: from 32 tonnes (ozone depleting potential) in 1991 down to 2 tonnes in 2004, as agreed by the phase-out schedule under the *Montreal Protocol* which sought to eliminate all use by 2005.

Agricultural greenhouse gas (GHG) emissions decreased by 35% from 1990 to 2002-04. This reduction compares to an overall decrease across the economy of 32%, and a commitment under the *Kyoto Protocol* to reduce total emissions by 6% over 2008-12. Agriculture's share of total GHGs declined to 13% by 2002-04. Much of the decrease in agricultural GHGs was due to lower livestock numbers (reducing methane emissions) and reduced fertiliser use (lowering nitrous oxide emissions) [18]. Projections suggest that agricultural GHG emissions will rise in the period from 2003-05 to 2008-12, as the farming sector expands following entry into the EU. Even so, agricultural GHG emissions are projected by 2008-12 to remain below their level of the early 1990s [18]. The decrease in the area under pasture over the period 1990 to 2003 has led to a reduction in ***soil carbon*** [18], but the planned afforestation of farmland under the *National Afforestation Programme* up to 2050 could increase carbon sequestration.

The agricultural sector has also contributed to lowering GHG emissions by reducing its on-farm energy consumption, but also by expanding renewable energy production. ***On-farm energy consumption*** decreased by 34% between 1990-92 and 2002-04 compared to a reduction of 2% for total national energy consumption, with farming contributing only 3% of total energy consumption. The overall reduction in agricultural production and energy support largely explains the decrease in energy consumption by farming, while higher energy prices have encouraged an improvement in farm energy use efficiency [32]. ***Renewable energy production*** from agricultural and other biomass feedstocks, including farm forestry, is being expanded but remains under 2% of total primary energy supply [20, 33]. Agricultural biomass provides feedstock for power, energy (biogas) and liquid fuel production (biodiesel and bioethanol), with one bioethanol plant using maize and other cereals producing 65 million litres annually, with considerable capacity to increase the use of agricultural biomass [20, 33, 34].

Evaluating the effects of agriculture on biodiversity since 1990 is complex. This is because of the inheritance from the previous centrally planned economy, which promoted intensive farming practices, including increased drainage and irrigation, leading to widespread damage to biodiversity and cultural landscapes [11, 14]. Over the 1990s the pressure on biodiversity rapidly diminished, especially with the reduction in the use of fertilisers and pesticides [22, 28]. But farming is now characterised by a dual structure of large corporate enterprises and small family farms, which have varying impacts on biodiversity: the smaller farms are commonly associated with less intensive production of potential benefit to biodiversity compared to corporate farms [14, 19, 35]. For example, small remnants of extensive farming systems persist, such as shepherding in the flats of the Great Plain and extensive fruit and grassland farming in the Orség region [11]. Even so, on both small and large farms the uptake of farming practices to help protect biodiversity is low, and investment in environmental protection is poor (*e.g.* manure storage).

In terms of agricultural genetic resources, there are* in situ *programmes and* ex situ *collections of agricultural genetic material [24, 36]. Crop varieties and livestock breeds used in production have increased in diversity. *In situ* regeneration of field crop and vegetable landraces are conducted under contract with farms in four to six ecologically different regions, with the number of landraces registered varying from 400 to 600 annually [24].

Research suggests that many small family farms and home gardens in rural areas are providing an ecosystem service by conserving *in situ* crop genetic resources [36, 37]. For livestock breeds there is little information on *in situ* or *ex situ* conservation programmes or the state of endangered breeds.

As agriculture is the major land user this has important implications for biodiversity. Nearly two-thirds of the country is farmed, among the highest share across OECD countries. Moreover, about 10% of the total land area is under nature protection, of which around 40% is farmed [11], including the extensively cultivated vineyards of the Tokaj region, a UNESCO *World Heritage Site* [38]. Of concern for wildlife habitat has been the nearly 8% reduction in farmland during 1990-92 to 2002-04, in particular, the conversion of ***semi-natural grassland*** to other land uses, mainly forestry. Conversion of farmland to forestry can involve both costs and benefits for biodiversity, especially by changing the mix of wildlife. In the late 1990s semi-natural grasslands, a habitat rich in wildlife including some endangered species such as the Corncrake (*Crex crex*) and Great Bustard (*Otis tarda*), accounted for around 15% of all farmland [14]. Increasingly, however, semi-natural grasslands are becoming fragmented, and the valued "puszta" landscapes are disappearing. The "puszta" landscape consists of a mix of dry steppes, wet meadows, alkali marshes, small wooded patches and small farms [11, 39].

Bird species are under threat not only from loss of agricultural habitats, but also because of changes in their management. Changes in farming practices towards more intensive methods, such as switching from hay to silage production; altering the timing of mowing grass for hay; and varying cropping patterns and rotations; have been detrimental to endangered birds such as the Corncrake and Great Bustard [11, 38, 39, 40]. In the late 1990s farming is estimated to have posed a threat to over 45% of important bird habitats through intensification and land use changes [41]. Nevertheless, given the more extensive system of farming in Hungary, compared to most regions of the EU15 over the 1990s, this has had a less harmful impact on biodiversity. For example, over the 1990s many birds which have bred relatively successfully in Hungary have declined in numbers in many EU 15 countries, such as the Skylark (*Alauda arvensis*), Corn Bunting (*Embrerisa calandra*) and Stonechat (*Embreriza citrinella*) [38, 39]. Other research has also shown a link between growing intensification of farming practices and declining wildlife. The numbers of two farmland game species, the Brown Hare (*Lepus europaeus*) and the Grey Partridge (*Perdix perdix*), have been in decline over many decades, although numbers stabilised over the 1990s [42]. Similarly the near extinction of the Meadow Viper (*Vipera ursinii rakosiensis*) is closely linked to the severe reduction and fragmentation of grassland meadows [43].

3.11.3. Overall agri-environmental performance

Overall agricultural pressure on the environment has been reduced since 1990. The transition to a market economy has resulted in a more extensive farming system, leading to a decrease in the use of purchased farm inputs (fertilisers, pesticides, energy and water) and water and air pollution. With the slight rise in farm input use since the late 1990s, however, concern over water pollution has grown in some regions. Even so, by 2005 farm input use remained below its peak of the late 1980s. Soil degradation, especially soil erosion, remains a widespread problem [11]. With respect to biodiversity, concerns relate to the conversion of agricultural habitats rich in wildlife (*e.g.* semi-natural grasslands) to other land uses, and in some cases the uptake of more intensive farm management practices on these habitats [11, 14, 19].

The agri-environmental information system does not fully provide the information required to effectively monitor and evaluate agri-environmental performance and policies. Government and relevant research institutions have been impeded by a lack of resources to improve data collection systems during the transition period. However, a stronger economy together with funding from the EU is beginning to help strengthen the agri-environmental monitoring system. Projects financed under PHARE, for example, are seeking to improve the monitoring system to assess the extent of water pollution from agriculture [11, 19]. Since 2004 under the *Less-favoured Areas* and agri-environmental schemes of the NAEP [5] one of the eligibility criteria is that every farmer has to record a register booklet (*Farm Management Record*), which contains much information relevant to agri-environmental performance and evaluation. The Agricultural Office has begun to process this database within the framework of the *Agri-environmental Information and Monitoring System* (AIMS), established by the Ministry of Agriculture and Rural Development in 2005. As agri-environmental schemes are expanded, this information will be important to help evaluate the effectiveness of these schemes.

Agri-environmental policies have been strengthened in the period since EU membership. Around 4% of farmland was included under the former *National Agri-environmental Programme* in 2003 [15], and the target for the *National Rural Development Programme* over 2004-06 is to achieve an uptake of land under agri-environmental schemes equivalent to over 10% of agricultural land (Figure 3.11.4) [11]. Given the extent of the soil erosion problem across Hungary, policy emphasis has focused on this issue, although policies to address agri-biodiversity issues are less well developed and this area needs to be strengthened, especially as much agricultural land continues to support a relatively rich and abundant wildlife compared to most EU15 countries [38, 39]. The *National Afforestation Programme*, which is seeking to expand the area forested from 20% in 2005 to 27% of the total land area by 2050, has important implications for agriculture as 80% of the planned new tree plantings would be on farmland. This programme has the potential to bring a number of environmental benefits, such as reducing soil erosion and pollutant run-off from farmland, and increase carbon sequestration to capture GHG emissions. However, only 44% of the planned new forest plantings under the Programme were established over the period 1991 to 2000 [11], while there are also concerns for afforestation of some marginal farming areas that are important for supporting wildlife, such as semi-natural grasslands.

While pressure from farming on the environment has been much reduced, problems still persist. To reduce soil degradation, especially ***soil erosion***, it will be important to increase the uptake of soil conservation practices, such as greater adoption of conservation tillage, continuous soil cover and establishing lines of trees and hedges against wind erosion [11]. More widespread adoption of soil conservation practices would not only bring benefits in reducing soil degradation, but also help toward reducing diffuse pollution and damaging impacts on biodiversity [40]. ***Agricultural pollution of water and air*** has been greatly improved, mainly as a result of the decrease in use of purchased farm inputs and despite a slight increase in input use since the late 1990s. By 2005 input use remained considerably below the peak of the late 1980s [13, 15]. But in some regions problems of pollution remain largely associated with large-scale intensive livestock operations, mainly due to a lack of investment in manure storage facilities and the low adoption rates, and inadequate knowledge, of nutrient management plans [11, 28]. Some support for farm use of energy and water inputs remains. ***Tax exemptions*** on fuel used by farmers provide a disincentive to improve energy efficiency and help further reduce greenhouse gas emissions, although

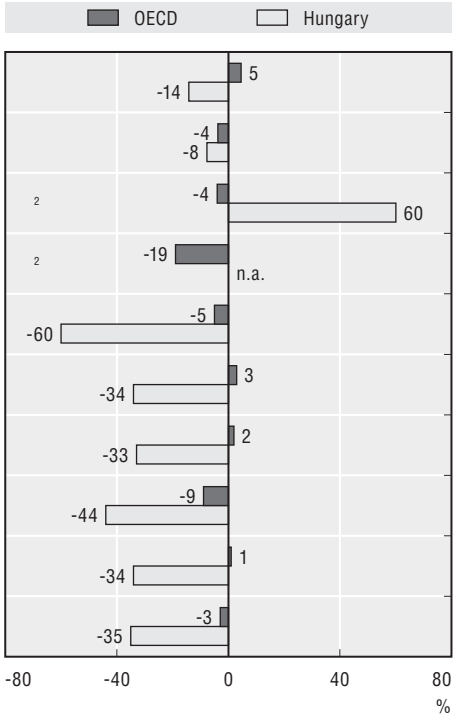
agriculture has reduced its GHG emissions, energy use and increased renewable energy production. Moreover, support for irrigation infrastructure does not provide incentives to conserve water resources, even though farmers pay a groundwater abstraction fee [17].

The pressure on biodiversity has eased as the intensity of farming has decreased, with numerous birds breeding successfully in Hungary relative to declining numbers in many EU15 countries. But land fragmentation and cessation of farming has been damaging to wildlife in some areas [11, 14, 38, 39]. The uptake of farming practices beneficial to wildlife is not widespread, although research suggests that many small family farms and home gardens in rural areas are providing ecosystem services by conserving *in situ* crop genetic resources and adopting extensive farming practices [36, 37]. Under the 2nd *National Environment Programme*, however, greater emphasis is being placed on biodiversity and landscape conservation, including for agriculture.

With the projected expansion of agricultural production from 2005 to 2015 the pressure on the environment could increase [18, 44]. The recent changes of CAP Reforms together with EU enlargement could lead to an increase in wheat and coarse grains production (but reduction in the area under these crops); and contraction in livestock output, notably dairy and beef up to 2010 [44, 45]. As a result there could be an overall rise in farm incomes and production concentrated on fewer farms [5]. These trends suggest further agricultural intensification, especially for cereals (higher production on a smaller area), although even by 2015 the Hungarian farming system is likely to be less intensive overall than in most EU15 countries.

Figure 3.11.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

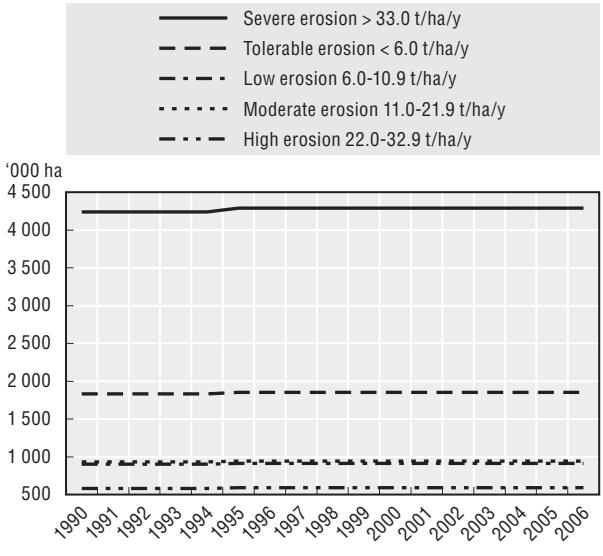
Variable	Unit		Hungary	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	86	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–491	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	37	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	–1	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–11 159	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–325	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–338	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	1.2	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–34	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–5 782	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

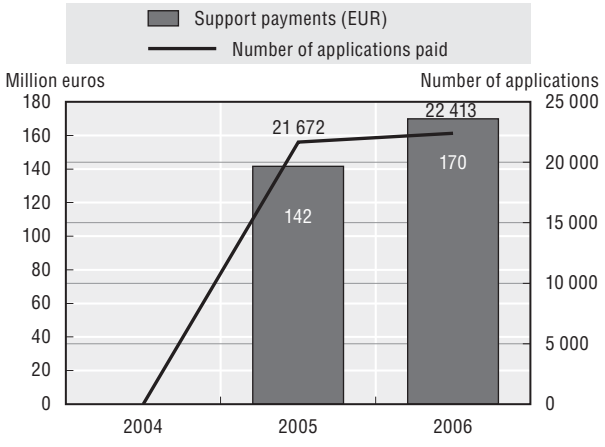
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.11.3. **Agricultural land affected by various classes of water erosion**



Source: Plant and Soil Protection Unit, Hungarian Ministry of Agriculture and Rural Development.

Figure 3.11.4. **Support payments for agri-environmental schemes and the number of paid applications**



Source: Report on the implementation of the National Rural Development Plan of Hungary in 2006, Ministry of Agriculture and Rural Development.

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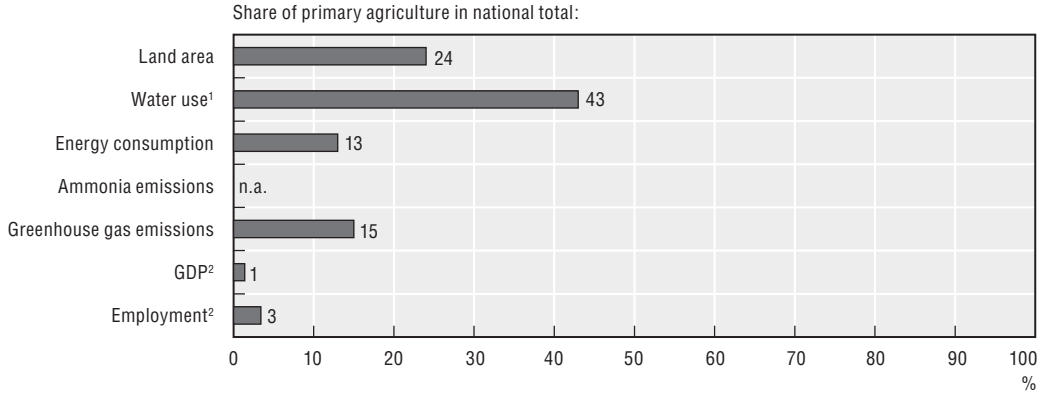
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3.12. ICELAND

Figure 3.12.1. **National agri-environmental and economic profile, 2002-04: Iceland**



StatLink http://dx.doi.org/10.1787/300367505347

1. Data refer to the period 2001-03.
2. Data refer to the year 2005.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.12.1. Agricultural sector trends and policy context

Agriculture is a small and proportionally declining sector in the economy, with its share of GDP and total employment at 1.4% and 3.4% respectively in 2005 [1] (Figure 3.12.1). Farming is limited by a combination of climate, the length of the growing season and topography, and accounts for only around 20% of the total land area, which is low by comparison with many other OECD countries [2].

Farming is dominated by livestock production based on forage grazing and silage production. Livestock products account for approximately 75% of agricultural value added. Overall the volume of agricultural production has increased by almost 6% between 1990-92 and 2002-04, but this has been mainly due to higher yields. Livestock numbers have declined for cattle (including dairy cattle), sheep, and poultry, risen slightly for horses used for recreational purposes, although the pig herd almost doubled in size. The decline in the livestock sector, especially sheep, is in part due to the reduction in market price support and export subsidies in the early 1990s [3, 4, 5]. Crop cultivation involves largely fodder crops (barley, and forage grasses), and a small horticultural sector mainly using greenhouses [6]. Although agriculture's share in total water use was over 40% in 2001-03, there is no use of irrigation as farming is entirely rain-fed. With the overall decline in livestock numbers and decrease in inorganic fertiliser use by over 20%, but little change in the area farmed between 1990-92 and 2002-04, agricultural production is becoming more extensive (Figure 3.12.2).

Agricultural support remains high compared to the OECD average. Support to farmers (as measured by the Producer Support Estimate, PSE) has decreased from 77% to 70% of farm receipts between 1986-88 and 2002-04, while the OECD average decreased from 37% to 30%. The share of output and input linked support, still accounts for 87% of the PSE in 2002-04, although it has fallen from almost 99% in 1986-88. Border measures and budgetary payments to farmers including area, headage, and deficiency payments are the main policy instruments supporting agriculture. A significant proportion of these payments are differentiated by region and farm size [4]. Total agricultural support, including border protection, was nearly ISK 17 (USD 0.21) billion in 2002-04, about 2% of GDP [4].

Greater policy attention is being given to agri-environmental concerns. Over the 1990s agricultural policy was based entirely on economic and social considerations, with environmental issues treated separately [3]. But in 2000 a seven-year voluntary cross compliance scheme was introduced (taking effect in 2003-04) linking sheep headage payments to the adoption of "*quality management*" which includes meeting the criteria of: good animal treatment; controlled use of chemicals and medicines; participation in a national breeding programme; and uptake of sustainable land use practices [5]. Sheep farmers meeting these criteria receive up to 22.5% higher payments in 2007 (up from 12.5% in 2003), than those farmers not adopting the scheme [7]. Two co-operative extension programmes involving farmers mainly in lowland areas have recently been established, "*Farmers heal the land*" and "*Better farms*", which aim to enhance sustainable land use and develop a conservation ethic [5]. Under these programmes the government funds up to 85% of project costs, such as revegetation, fertilisers, and fencing to control grazing on fragile land [3, 8, 9]. Grazing quotas can be imposed if there is evidence of overgrazing [3].

Agriculture is also impacted by a range of national environmental and taxation policies and international environmental agreements. The 2002 *Soil Conservation Strategy* (SCS), covering the period 2003 to 2014, is the main environmental policy affecting agriculture, with emphasis placed on: curbing soil erosion; revegetation; monitoring land conditions; land use management; and research and dissemination of information [8, 10]. Total government expenditure under the SCS (mainly for agriculture) was around ISK 420 (USD 6) million in 2004 [3, 7, 8]. Farmers receive grants for afforestation under the *Regional Afforestation Projects*, to address problems of soil erosion, biodiversity conservation and carbon sequestration [11]. As part of its environmental recycling policy, ***taxes*** are applied to fund municipal recycling and recovery costs for a range of waste products, including farm plastic waste (*i.e.* silage packaging film) and pesticide containers [12]. From 2005 farmers benefited from a diesel fuel tax concession which amounted to ISK 238 (USD 3) million of tax revenue forgone in 2005 [4]. Agriculture is also impacted under ***international environmental agreements*** including commitments to lower emissions of: nutrients into the Atlantic and North Sea (*OSPAR Convention*), methyl bromide (*Montreal Protocol*) and greenhouse gases (*Kyoto Protocol*). In addition, reducing biodiversity loss is part of Iceland's commitments under the Convention of Biological Diversity, and limiting land degradation as part of the UN *Convention to Combat Desertification*. Meeting the commitments under the UN Conventions on climate change, desertification and biodiversity are a key element of the *Soil Conservation Strategy*.

3.12.2. Environmental performance of agriculture

The contraction and extensification of agriculture since 1990 has reduced environmental pressure, especially concerning soil erosion. Given the dominance of pastoral farming, the general fall in livestock numbers has helped to ease environmental damage to soils, biodiversity and led to the reduction in greenhouse gas emissions. Overgrazing in some regions, however, continues to be a problem in meeting soil conservation objectives [4, 7, 10]. Organic farming accounted for under 1% of farmland and all farms in 2002-04, and has grown slowly since 1990 [13].

Soil erosion remains the major agri-environmental challenge to be addressed. The share of the total land area subject to a medium to severe risk of soil erosion remains high (this is measured in terms of landforms and in tonnes of soil loss). Severe and very severe erosion occurs on about 17% of the country, and medium erosion on an additional 22%. When glaciers, water bodies and high mountains are excluded, about 50% of the land is subject to substantial erosion [7, 10 14]. Concerning agricultural land 5% of permanent grasslands (*i.e.* 95% of agricultural land) are affected by moderate to severe water erosion and 50% by wind erosion [3].

Overgrazing is exacerbating soil erosion problems in some areas although this pressure is declining and the problem is being addressed [15]. Many of the ecosystems that are being used for grazing by sheep have vulnerable vegetation and soils, and a harsh climate [7]. Soil erosion is particularly acute in the communal highland grazing areas, which provide pasture for about 10% of the national sheep flock [3, 5]. The increase in horse numbers, mainly for riding, is beginning to exert some pressure on soil quality, although most horses are grazed on the less fragile lowland areas [3, 15]. Under farm forestry schemes over 1 000 hectares annually were being afforested over the period 1990 to 2005 (Figure 3.12.3), which was about a fourfold increase over the levels achieved during the 1970s and 1980s [3, 15]. The rapid increase in the area being afforested, from around 1 000 hectares in 1990 to an accumulated total of over 22 000 hectares by 2005 (Figure 3.12.3) (and over the same period the number of farmers participating in afforestation projects rising from around 300 to over 500), is also contributing to soil conservation goals, as well as bringing benefits for biodiversity and carbon sequestration [15].

Agriculture pollution of surface water is at very low concentrations compared to many other OECD countries [3, 10]. This reflects the extremely low levels of agricultural nutrient surpluses (surpluses are the quantity of nutrient inputs minus outputs of nutrients, nitrogen – N – and phosphorus – P) and use of pesticides compared to the OECD average (Figure 3.12.2). Agriculture, however, is the major source of nutrients in rivers and lakes. An outbreak of Campylobacter bacteria in drinking water in 1999, connected to the poultry industry, prompted the government to take measures to address the problem and the number of cases has been lowered [10].

Agricultural nitrogen and phosphorus balance surpluses declined over the period 1990-92 to 2002-04, mainly due to the decrease in overall livestock numbers (*i.e.* less manure) and use of inorganic fertilisers. The use of inorganic phosphate fertilisers, however, declined by 25% over this period compared to a reduction of 12% for nitrogen fertilisers. Moreover, the intensity of nutrient surpluses (expressed as kg of nutrients per hectare of agricultural land) was among the lowest across the OECD in 2002-04 (Figure 3.12.2). The trends in nutrient surplus balances are consistent with the low concentrations of nitrates and phosphorus in rivers and lakes, which overall were below national drinking and

environmental limits during the period 1996 to 2004 [10, 15]. This is in part because of the high flow rates in rivers, while most groundwater abstractions are upstream from the main cultivated areas were the intensity of fertiliser use is highest [3]. It is not clear due to a lack of monitoring data, however, the impact of nutrient flows into rivers and coastal waters on aquatic ecosystems [3]. The growth of the pig industry is a concern for water pollution, as pig slurry must be spread on land, since the prohibition in 1999 of the disposal of pig slurry into the sea [3].

Pesticide use is extremely low mainly attributed to the dominance of livestock in the agricultural sector. Pesticides in domestic foodstuffs are reported to be well below permissible limits believed to be hazardous to human health, although there are no monitoring data on concentrations of pesticides in water bodies [10, 15]. All the most toxic and persistent pesticides have been prohibited since the 1980s, including DDT and methyl bromide [16].

Agricultural greenhouse gas (GHG) emissions decreased by 10% over the period 1990-92 to 2002-04, compared to a reduction of 3% for the OECD on average (Figure 3.12.2) [6]. Total national GHG emissions rose by 6% and farming contributed 15% of total GHG emissions (2002-04), while its commitment under the *Kyoto Protocol* is an increase of total GHGs of 10% from the 1990 base year by 2008-12. The decline in agricultural GHGs is largely due to falling livestock numbers and lower fertiliser use, offset to a limited extent by higher direct on-farm energy consumption. ***Agricultural energy consumption*** grew by 7% between 1990-92 and 2002-04 compared to a 40% rise in national total energy consumption over this period, consequently farming only accounted for 13% of total energy consumption by 2002-04 (Figure 3.12.2).

Carbon sequestration is increasing as a result of the revegetation and afforestation of farmland (Figure 3.12.3) [6]. Agriculture has also contributed to carbon sequestration through the rise in soil carbon in restored wetlands on farms and from reduced soil erosion rates [6]. Projections suggest that the continuation of programmes that promote revegetation and afforestation are likely to lead to a further rise in carbon sequestration in the period up to 2008-12 [6]. But the continued high levels of soil erosion in some farming regions is leading to ongoing losses of soil organic carbon, to the detriment of carbon sequestration and the quality of farmed soils [17].

Overall agricultural pressure on biodiversity has diminished since 1990. This is a marked change from the trend in earlier decades when agricultural practices led to the drainage of wetlands and high rates of soil erosion to the detriment of biodiversity. In terms of ***agricultural genetic resources*** Icelandic farming, and livestock in particular, enjoy a special position relative to other countries. For each type of livestock there is usually only a native breed whose origins can be traced back to the settlement of the country [18]. These breeds are believed to have been subject to extremely limited cross-breeding with foreign breeds, and have undergone selective breeding such that the frequency of disease in the stock is low. Imported breeds, however, are important for beef and intensive pig and poultry production. All cattle and sheep in Iceland are registered in breeding databanks, and although some breeds have in the past been close to extinction *in situ* and *ex situ* conservation programmes have improved the situation, such as for the goat [19].

The restoration of wetlands on agricultural land has been important as they provide habitat for a wide variety of flora and fauna. In 1999 a programme was launched to restore wetlands, after a period from the 1950s to the 1990s when the government had provided

support to farmers to drain wetlands, although few intertidal mudflats were drained [3, 10]. With the abolition of support in the mid-1990s for wetland drainage, the total area of restored wetlands rose on a small scale from 35 hectares in 1996 to an accumulated total of almost 500 hectares of wetlands restored by 2005 (Figure 3.12.4) [15]. These changes are significant as Iceland supports internationally important bird populations that require wetland habitats, such as the Golden Plover (*Pluvialis apricaria*), Purple Sandpiper (*Calidris maritime*), Whimbrel (*Numenius phaeopus*) and Black-tailed Godwit (*Limosa limosa*) [20].

Lowering grazing intensity and increasing afforestation is helping to limit degradation of soil and vegetation to the potential benefit of wild species. But while these changes in land use and management can be beneficial to some species they are harmful to others that depend on extensive grazing or open spaces rather than forested areas. These diverse impacts on species are revealed by recent research studies of bird species that prefer wetlands and beetles (*Coleoptera*) preference for hayfields and pastures [20, 21]. There has also been a ***growing public appreciation for rural landscapes*** with some farmers beginning to respond to this demand. There is an increasing shift on farms in combining low intensity farming practices with providing agri-tourism services such as cottage rental, horse rentals, angling and other services linked to agricultural landscapes [22].

3.12.3. Overall agri-environmental performance

Overall the pressure from agriculture on the environment has decreased. With the dominance of pastoral farming in the agricultural sector, the decline in livestock numbers since 1990, especially the national sheep flock, but little change in the area farmed, the intensity of agriculture has diminished. Despite these improvements agriculture remains a major contributor to soil erosion, and as a consequence, a continued threat to biodiversity.

A substantial effort is underway to improve the monitoring of agri-environmental performance. A joint project – *The Icelandic Farmland Database* – between several government agencies and the Farmers Association was initiated in 2000 to collect primary data to help assess whether there is sufficient vegetation for grazing [5, 10]. This database has been established to both help guide soil conservation programmes and also as information for the "*quality management*" scheme linking sheep headage payments to environmental criteria. As the database is developed it will be capable of being used for other agri-environmental monitoring purposes, such as tracking biodiversity and carbon sequestration on farmland [5]. In a number of areas, however, agri-environmental monitoring needs to be strengthened to better assist policy makers and farmers. There are no monitoring data on concentrations of pesticides in water bodies, while the lack of wild species monitoring affected by agricultural activities (*e.g.* farmland bird populations) is a limitation in assessing agri-environmental performance. Also there is no monitoring of the extent and trends in the eutrophication and acidification of land and freshwater resources from agricultural nitrogen run-off, agricultural ammonia emissions, although other sources of acidifying emissions are measured. Ammonia emissions from livestock, as an acidifying substance of both land and water, could be important given the size of livestock numbers (Iceland is not a signatory to the *Gothenburg Protocol on Long-range Transboundary Air Pollution*).

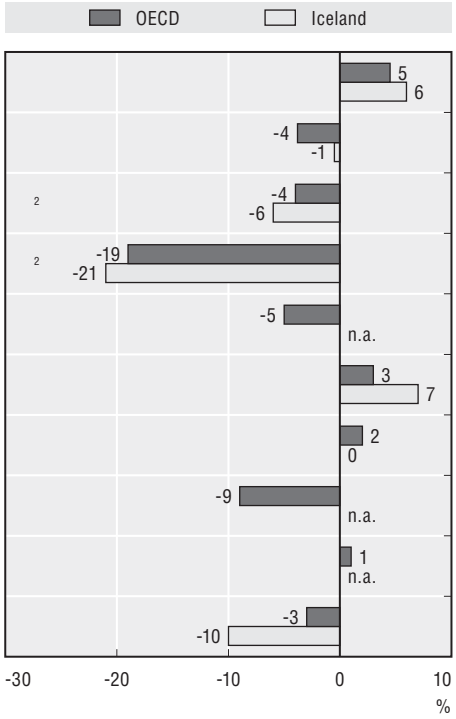
There has been a shift toward greater use of agri-environmental measures, brought about in part by the national soil erosion assessment programme, which has highlighted the extent and severity of soil erosion on agricultural land. The new awareness of the problem led to an agreement whereby a part of the headage payments sheep farmers receive is

linked to sustainable land use. About 40% of sheep farmers, as well as a number of farms rearing horses and other land users, are participating in this and other related agri-environmental programmes [5].

Despite progress in reducing pressures from grazing, concerns over soil erosion remain high. While the government's recent attempt to address soil erosion by making a thorough physical assessment and tying some farm payments to meeting environmental conditions, the most production distorting policies still account for over 80% of agricultural support [3, 4]. Moreover, sheep farming persists on land that is already eroded or highly susceptible to erosion, especially the common areas in the highlands [3]. Grazing quotas can be imposed to limit overgrazing but this measure is rarely enforced, while livestock density regulations adapted to the carrying capacity of the soil and prohibiting grazing on the most fragile soils are not part of the *Soil Conservation Strategy* (SCS) [3]. Property rights further complicate the implementation of the SCS as the government has legal responsibility to control erosion, while farmers own or have grazing rights over much of the country [3]. But progress has been made in establishing the *Farmland Database* which is a key element for an effective land use policy.

Figure 3.12.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

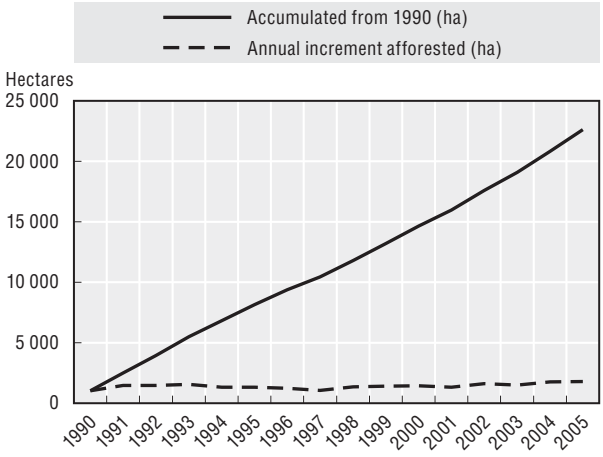
Variable	Unit		Iceland	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	106	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–13	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	7	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	1	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	n.a.	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+21	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+0	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	n.a.	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	n.a.	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–57	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

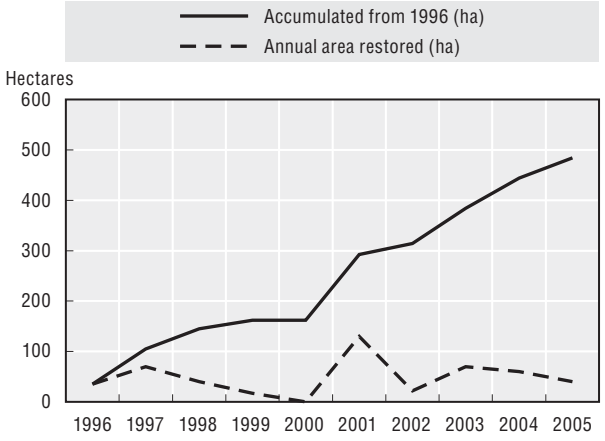
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.12.3. **Annual afforestation**



Source: Annual data of number of planted seedlings in Iceland (Annual report of the Icelandic Forest Association 1991-2006). Data from the Icelandic National Forest Inventory (unpublished data).

Figure 3.12.4. **Annual area of wetland restoration**



Source: Report by the Ministry of Agriculture, Iceland (in Icelandic).

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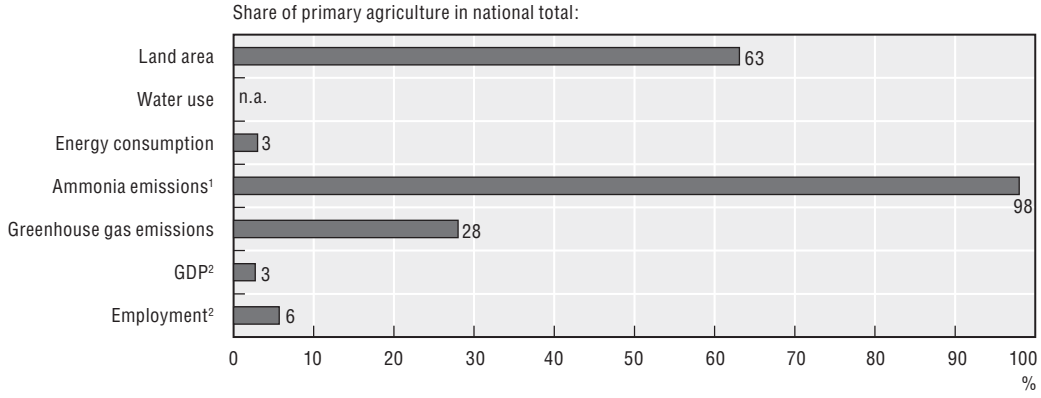
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3.13. IRELAND

Figure 3.13.1. **National agri-environmental and economic profile, 2002-04: Ireland**



StatLink http://dx.doi.org/10.1787/300466256078

1. Data refer to the period 2001-03.
2. Data refer to the year 2005.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.13.1. Agricultural sector trends and policy context

Primary agriculture's contribution to the economy is rapidly declining [1, 2]. Between 1990 and 2005 agriculture's contribution to GDP and employment more than halved to 2.7% and 5.7% respectively [1, 3] (Figure 3.13.1). The past decade has been characterised by farm families increasing participation in the non-farming activities of the rural economy [4].

Agricultural production is intensifying on a reduced area of land and concentrated on fewer farms [1]. Over the period 1990-92 to 2002-04 the volume of agricultural production rose by over 1%, but the total area farmed declined by 2.6% (Figure 3.13.2). Nearly 45% of farms are less than 20 hectares in area and over 40% of farmers work part-time [1]. Between 1991 and 2003 agricultural productivity (gross value added per employee annual average) grew by 3.2%, compared to 3.4% for the whole economy, partly reflecting the substitution of labour by purchased inputs [5]. The volume of purchased farm inputs rose over the period 1990-92 to 2002-04: inorganic nitrogen fertiliser by +1%; pesticides +5%; and direct on-farm energy consumption by +37%; although inorganic phosphate fertiliser use fell by –31% (Figure 3.13.2).

Pastoral farming dominates the agricultural economy. Livestock and livestock products accounted for almost 70% of the total value of agricultural output in 2005, with dairying and beef production accounting for 55% of the value of total output [3]. Sheep numbers, in particular, have shown great variability, with numbers peaking at nearly 9 million in 1992 (June enumeration), from around 3 million in 1980 largely due to EU payments, but decreasing to just over 6 million by 2005 [1, 6]. There are increasing structural and regional

differences in farming and land use. Livestock production is mainly concentrated in eastern and southern commercially viable farming areas. The west and border regions, however, are dominated by extensive cattle and sheep farms on which there is some tree planting, less dairying, and higher levels of participation in agri-environmental schemes [4].

Agriculture is mainly supported under the Common Agricultural Policy (CAP) with support also provided through national expenditure within the CAP framework. Support to EU15 farmers on average declined from 41% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate – PSE). This compares with the OECD average of 31%. Nearly 70% of EU15 support to farmers was output and input linked in 2002-04, compared to over 90% in the mid-1980s. These are the forms of support that most encourage production [7]. Total budgetary support to Irish agriculture was over EUR 3 (USD 3.75) billion in 2005, of which around 50% was nationally financed [1]. Agri-environmental measures in Ireland accounted for about 9% of total budgetary support in 2005.

Agri-environmental measures were first introduced in the early 1990s. Such measures are mainly used to control water and air pollution and provide incentives to enhance biodiversity and landscape conservation [1, 6, 8]. A key measure to promote environmentally sensitive farming is the voluntary nationwide *Rural Environment Protection Scheme* (REPS), introduced in 1994 in response to EU agri-environmental regulations. Objectives of the scheme include: protecting wildlife habitats and endangered species; landscape protection; establishing farming practices to address wider environmental problems (*e.g.* water pollution); and producing quality food through extensive and environmentally friendly practices. Expenditure on REPS totalled EUR 1.5 (USD 1.9) billion between 1994 and 2004 and by 2005 it was EUR 283 (USD 354) million covering 37% of farmers and 40% of farmland [1, 9]. Farmers must sign up for REPS for 5 years and payments are conditional on undertaking a basic set of farming practices, such as having a nutrient management plan [1, 8, 10]. Supplementary REPS payments are also available to farmers, designed to deliver specific environmental outcomes, mainly: the protection of wildlife habitats; long-term set aside for riparian zones; conservation of local livestock breeds; and to promote organic farming. Almost a third of farmers in 2005 who undertook supplementary measures chose the organic farming option [1].

In addition to REPS there are other agri-environmental measures. The *Grant Aid for the Development of the Organic Sector* scheme also provides investment assistance to organic farmers and organic food processors. Investment aid for animal manure storage, winter housing for cattle and sheep, silage storage and equipment for spreading animal wastes is provided to farmers under the *Farm Waste Management Scheme*, up to an eligible investment maximum of EUR 120 000 (USD 150 000) per holding from 2006, with total expenditure under the scheme between 2001 to 2005 being nearly EUR 66 (USD 82) million. Farmers with land under shared ownership ("commonage" land) and participating in direct payment and agri-environmental schemes must implement the *Commonage Framework Plan* in order to be eligible for support. The Plan mainly seeks to prevent overgrazing on sensitive areas, with permanent stock reductions for commonages introduced since 2002.

Agriculture is also affected by national environmental and taxation policies. The National Action Programme under the Nitrates Directive (2005) seeks to meet obligations under the EU *Nitrates Directive* operating for a period of 4 years, with implementing Regulations taking

effect from February 2006 [11]. The key measures of the Programme include: regulating the timing and practices for the application of fertilisers; limiting application of fertilisers; and setting storage requirements for livestock manure and general provisions on storage management. Income tax relief for capital expenditure on pollution control facilities is granted to farmers with nutrient management plans [11]. Regulatory measures under the *Water Pollution Act*, implemented by local authorities, are used to address water quality issues by targeting the use of chemical fertilisers, storage and application of manure, and by setting concentration standards for nutrients and pesticides in water bodies. Under the *Phosphorus Regulations* concentration levels and biological status targets are set to reduce eutrophication [6]. The *Use of Sewage Sludge in Agriculture Regulations* place limits on heavy metal pollution from spreading sewage sludge on farmland. The *Farm Plastics Regulations* facilitate the improved recovery of waste farm plastics, with 9 000 tonnes recovered in 2003 and a target of 75% recovery of plastics by 2008. Under the ***Integrated Pollution Prevention and Control*** (IPPC) regime intensive livestock farms must develop an annual nutrient management plan, with around 90 piggeries and 3 poultry units already licensed. However, intensive dairying and beef farms are not subject to IPPC licensing [6].

Excise duty on kerosene and non-automotive liquid gas was halved in 2006 and reduced to zero in 2007, but the budget revenue forgone from this tax exemption for agriculture is unknown. Measures to increase the uptake of ***biofuels*** include: excise duty exemption of over EUR 200 (USD 250) million over the period 2006-10; reduction in vehicle registration tax for vehicles capable of operating on biofuels; investment grants for biomass heat and power projects; and payments of EUR 45 (USD 56) per hectare for energy crops since 2004 [12, 13]. Farmers are also provided support, of nearly EUR 111 (USD 125) million in 2005, for afforestation projects, especially in less-favoured areas.

International environmental agreements important to agriculture include: those seeking to curb nutrient emissions into the Atlantic (*OSPAR Convention*); the *Gothenburg Protocol* concerning ammonia emissions [14]; and commitments under the *Convention of Biological Diversity*. Ireland's vision of biodiversity conservation is articulated in the *National Biodiversity Plan*. Under the *National Climate Change Strategy*, Ireland's response to its commitments to reduce greenhouse gases (GHGs) under the *Kyoto Protocol*, it has set a target to reduce agricultural GHGs by the equivalent of a 10% reduction in livestock numbers below business as usual 2010 projected levels [6, 15].

3.13.2. Environmental performance of agriculture

The intensification of agriculture over recent decades has led to increasing environmental pressure, especially concerning water pollution [6]. Reducing ammonia and greenhouse gas emissions are also important environmental problems, reflecting the predominance of livestock. Overgrazing in some Western regions has been a concern for soil erosion, while structural changes, especially the shift toward fewer but more intensively farmed operations, have led to concerns regarding the conservation of biodiversity and landscapes. As agriculture is largely rain-fed its use of water resources is small with significantly less than 1% of farmland irrigated, mainly for vegetable production [16]. Organic farming accounted for less than 1% of total agricultural land in 2002-04 compared to an EU15 average of almost 4%, despite rapid growth during the late 1990s. Some 90% of land organically farmed is utilised to produce pasture and fodder [1, 17, 18].

Overall soil quality is high but has come under growing pressure, especially because of overgrazing [4, 6, 17, 19, 20]. Existing information on soil quality is fragmented as there is no

national soil monitoring network [19, 20]. Over the past 20 years there has been greater pressure on soil quality notably from overgrazing in hill areas, and also from the erosion of river banks from trampling by livestock, and land use changes, such as the increase in the area of artificial surfaces (buildings, roads, etc.) [4, 6, 19]. Overgrazing has been mainly associated with sheep, but since the early 1990s, with falling sheep numbers (partly in response to the *Commonage Framework Plan)*, there was a recovery of eroded hillsides in many areas [17]. For some hillsides in the West (notably Galway and Mayo), however, erosion is still apparent, especially on peatlands where sheep overgrazing has led to removal of vegetation, depletion of bog species and erosion of hillside peat and riverbanks [6, 17, 20, 21]. Erosion of riverbanks from livestock trampling has caused widening of rivers in such areas and made rivers highly unstable from one flood event to another, eliminating salmon and trout spawning in some cases [6].

Agriculture is a major and widespread cause of water pollution, including in rivers, lakes, groundwater and coastal waters [4, 6, 17, 22]. As a consequence addressing water pollution from agricultural sources, as well as sewage treatment, remains a key challenge for both national and local authorities in meeting the targets under the EU *Water Framework Directive* [23]. Pollution of water from farm pesticide use is very low given the dominance of pastoral livestock farming [24], although occasional pollution incidents involving sheep dip compounds have been recorded [6, 19, 22]. A growing concern is the contamination of water through livestock pathogens [4, 22].

Between 1990-92 and 2002-04 agricultural nutrient surpluses rose with respect to nitrogen, but sharply declined for phosphorus (Figure 3.13.2) (nutrient surpluses are the quantity of nutrient inputs minus outputs of nutrients, nitrogen [N] and phosphorus [P]). The increase in N surpluses has resulted from the rise in N inputs (inorganic N fertiliser and manure) relative to the reduction in N uptake by crops and pasture. But while inorganic N fertiliser use rose from 1990 to 1999, it returned to 1990 levels by 2004. The large decrease in P surpluses was due to the fall in inorganic P fertiliser use. Nutrient use efficiency (the ratio of N/P output to N/P input) was above the EU15 average between 1990-92 and 2002-04, while the level of nutrient use intensity (N/P per hectare of agricultural land) was the same as the EU15 average for nitrogen, but below it for phosphorus (Figure 3.13.2). The reduction in P intensity (–35%) was less than the EU15 average (–48%) over the period 1990-92 to 2002-04, although the rising trend in N intensity (+9%) compares to an overall decline for the EU15 average (–26%).

Agriculture accounts for the greater and rising share of water pollution from nutrients [17]. About one-third of slight and moderate eutrophication of rivers (Figure 3.13.3) is due to agriculture (2003-05), with over 70% of phosphorus and 80% of nitrogen reaching inland waters originating from farmland in 2004 [11]. Western regions show much lower levels of pollution compared to southern and eastern regions [25]. The adverse impacts of eutrophication on water bodies include damage to aquatic ecosystems, such as algal growths and fish kill events, and also higher costs for water treatment [6, 17, 22]. Nevertheless, the share of agriculture in total fish kills declined from nearly 60% in 1992-94 down to 22% by 2005, partly due to the effect of measures by local authorities, the Central and Regional Fisheries Boards and the Department of Agriculture and Food [6, 17, 22, 26]. Nitrate levels rose between the 1980s and 2005 in 9 of 11 large rivers that are monitored, which has led to the depletion of the nitrate sensitive protected Pearl Mussel (*Margaritifera margaritifera*) in some rivers [21, 26]. Aerial surveys have shown that damage to riverbanks by cattle and release of

nutrients into rivers from spreading manure and fertilisers close to riverbanks, is common and widespread [21].

Most drinking water quality meets required standards. Between 1998 and 2005 there was a rise in the share of groundwater monitoring sites with nitrate levels greater than the Irish drinking water guide level of 25 mg/l NO_3, mainly related to agriculture [26]. Groundwater accounts for over 15% of drinking water nationally and more than 85% in some rural areas [17, 26]. Drinking water contamination from pathogens, some resulting from land spreading of manure, is a problem in certain locations especially those using groundwater [6, 17, 22]. But between 1995 and 2005 there were less faecal coliforms monitored in groundwater, with a rise in the share of samples showing zero contamination [17, 26].

Soil phosphorus levels are rising despite the decline in P surpluses [6, 21]. Soil analysis indicate that an estimated 24% of soils contain P levels in excess of that needed to produce financially viable crop yields [21, 27]. This raises concerns over water pollution, as reducing the build-up of P in soils can take decades [6]. Estimates for 1998 indicate a surplus of 48-60 000 tonnes of P applied to farmland annually (an average of around 43 000 tonnes of inorganic P fertiliser were applied during the 2002-04 period). This unnecessary P fertiliser application is estimated to cost EUR 30 (USD 33) million annually [21]. While these P losses are not regarded as significant in economic terms, as they are less than 5% of the cost of P applied, they are significant for the environment because of the resulting eutrophication of water bodies [27]. The national P balance showed a surplus of about 6kg/hectare during the period 2002-04 (although this reveals the potential to pollute rather than actual pollution), while a surplus of 5kg/hectare can give rise to P concentrations in surface waters well in excess of the *Phosphorus Regulation* target of less than 30 μg P/litre [6].

Uptake of nutrient management plans is low and there are deficits in slurry storage facilities [21]. Farmer uptake of nutrient management plans is low in comparison with some EU countries which have similar nutrient surplus problems. In 2003 the share of farms and agricultural land under a nutrient plan was around 30%, compared, for example, to over 60% in Finland, Germany and the Netherlands [16]. Research indicates that there is a substantial deficit in slurry storage capacity on farms [21]. Local authorities have also identified other practices that may be contributing to nutrient pollution of water bodies including: manure and fertiliser spreading on over-enriched land or under unsuitable weather and soil conditions; and uncertainty over future policy developments at the EU, national and at local level, acting as a disincentive to investment in facilities that improve nutrient management on farms [21]. A further challenge faces the intensive livestock industry, especially pig and poultry farms, in terms of a shortage of land on which to spread manure. This is due to: competition between such farms for land for manure spreading; the previous history of over fertilisation resulting in excessive P accumulation in soils; and the recent introduction of the *Nitrates Regulations* [4, 6].

Growth in agricultural ammonia emissions has been above the EU15 average. Agriculture accounted for 98% of national ammonia emissions and 60% of all acidifying emissions in 2004 [28]. This growth in ammonia emissions of 2% compares to a reduction of –7% for the EU15 between 1990-92 and 2001-03 and a 24% decrease in acidifying emissions from all Irish sources over the period 1997 to 2004 (Figure 3.13.2) [28]. While there was a steady rise in ammonia emissions over the 1990s, the recent reduction in nitrogen fertiliser use and livestock numbers contributed to a downturn in emissions between 1999 and 2004 [17, 28].

Livestock manure accounts for about 85% of agricultural ammonia emissions and fertilisers account for much of the remainder [14, 17]. Ireland has agreed to a ceiling for total ammonia emissions of 116 000 tonnes by 2010 under the *Gothenburg Protocol*. By 2004 emissions totalled 114 000 tonnes, so Ireland was already compliant with the 2010 ceiling, and projections to 2010 suggest further reductions may occur [17, 28]. While the growth in agricultural ammonia emissions up to 1999 contributed to increased pressure on ecosystems (terrestrial and aquatic) sensitive to excess acidity, there is little research on these impacts.

Agricultural greenhouse gas (GHG) emissions decreased by 2% between 1990-92 and 2002-04 (Figure 3.13.2). Emissions in the agriculture sector increased over the course of the 1990s, but since the end of that decade have reduced, resulting from a decline in both livestock populations and fertiliser use, with the net result that emissions from agriculture in 2004 were marginally lower than in 1990. This compares to a reduction of –7% in agricultural GHG emissions for the EU15, but a 24% rise in total GHG emissions in the Irish economy as a whole over the period 1990-92 to 2002-04. Under the *Kyoto Protocol* and the EU *Burden Sharing Agreement* Ireland can increase total GHG emissions up to 13% by 2008-12 from the 1990 base year, although it has set its own target to reduce methane emissions, equivalent to a 10% reduction in livestock numbers below business as usual 2010 projected levels [15]. The share of agriculture in national GHG emissions was among the highest across OECD countries at 28% in 2002-04, dropping from 36% in 1990, with methane from livestock, and nitrous oxide from fertilisers and manure applied on soils the main sources of farm GHGs [15]. Research suggests that under EU 2003 CAP reform the farm sector would contract, and, as a result of lower livestock numbers and fertiliser use, agricultural GHGs are projected to decrease to a level variously estimated at between 12% and 16% below their 1990 level [15, 29, 30].

The net annual decrease of carbon storage in soils between 1990 and 2000 was 2.7 million tonnes, equivalent to 14% of total national greenhouses gas (GHGs) emissions in 2000. This was mainly due to industrial peat extraction [33, 34]. Schemes to encourage afforestation of farmland, however, have the potential to increase carbon sequestration. These schemes have led to 244 000 hectares of farmland being converted to forestry between 1990 and 2004. However, the national forest area represents only 10% of the total land area compared to the EU15 average of about 35% [15].

The rise in direct on-farm energy consumption by 37%, compared to a 53% rise for the rest of the economy, over the period 1990-92 to 2002-04 (Figure 3.13.2). While the rise in farm energy consumption contributed to higher GHG emissions, agriculture's share of total energy consumption is low at 2.6% (2005). Agriculture's role in ***renewable energy production*** was minimal between 1990 and 2005. However, Ireland's first solid biomass fuelled combined heat and power plant began operating in 2003, largely using forestry biomass, while there is a small number of farm based biogas digesters, but no central anaerobic digestion facility [31, 32]. To meet the *EU Biofuel Directive* by 2010 (*i.e.* 5.75% national market penetration of biofuels in transport fuels) would involve a significant change in land use and in energy policy, or necessitate higher imports, although recent policy measures have been introduced to encourage biofuel development [1, 12, 13, 15].

Overall agriculture has had adverse impacts on biodiversity since the early 1990s, part of a longer term trend linked to the accelerated development of agriculture, especially since Ireland's entry into the EU [35]. The adverse impacts of agriculture on biodiversity are

largely the result of overgrazing in certain areas, changes in grassland management, and land use changes [6, 10]. Consequently more wild species and high nature value habitats associated with farming are being confined to marginal areas [10].

The genetic diversity of most crop varieties and livestock breeds used in production increased over the period 1990 to 2002. However, there was a reduction in varieties of barley, pulses and forage used in production [16], but there are *in situ* and *ex situ* crop conservation programmes through the *REPS* and supported by the Irish Seed Savers Association [35]. There are also a number of endangered livestock breeds (cattle, sheep, poultry, horse and pony breeds) [16, 36]. Various livestock breeding associations play a key role for *in situ* conservation, but *ex situ* conservation is only limited to Kerry cattle, despite other livestock breeds being endangered [36, 37].

Agriculture accounted for over 60% of land use in 2002-04, emphasising the importance of agriculture for biodiversity. While there was only a modest decline in the total area farmed between 1990-92 and 2002-04 (2.6% compared to a 5.2% fall for the EU15), more significantly for wild species were the changes between different forms of agricultural land use and in land management practices, especially with respect to grassland, which accounts for over 90% of farmland. Some semi-natural farmed areas (*i.e.* permanent pasture and rough grazing) were converted to forest, although some arable land was converted to pasture [6]. Grassland management also intensified, part of a longer-term trend, including the switch from hay to silage production [6]. There has also been increasing pressure on certain marginal farmed habitats, including some with designations as *Special Areas of Conservation* and *Natural Heritage Areas*, such as: limestone pavements (notably the Burren plateau); turloughs (vegetation covered limestone basins); machair (Atlantic dune grassland); orchid rich grassland; and salt marshes. The greater pressure on these habitats has been because of overgrazing, drainage and reclamation to more intensive land uses [6, 38]. Harvesting of peat moss and turf is an important industry, but there is now a moratorium on establishing new turf cutting of raised bogs [35]. Peatland habitats have also been degraded from overgrazing by sheep in hilly areas [19].

There have been significant declines in farmland bird populations. This has largely been associated with the reduction in the area and quality of semi-natural farmed habitats [39, 40, 41]. In the period from 1998 to 2004, however, the *Countryside Bird Survey*, covering 57 species, revealed that there were significant increases in 18 species and declines in 10 (Figure 3.13.4) [42]. The Corncrake (*Crex crex*) is the only Irish breeding bird which is threatened with global extinction. Corncrakes are dependent on low-intensity semi-natural farmed habitat, especially lowland rough grazing. With the decline in rough grazing the breeding population of this species decreased rapidly from the 1960s, down from 900 males in 1988 to 174 by 1993, but from 1993 to 2004 the population stabilised [43]. The impact of agriculture on other wild species is poorly monitored. Through the REPS there is potential to ease the pressure from farming activities on bird populations and other forms of biodiversity. Research has shown that in some areas where habitat conservation has been under the REPS and other schemes, bird populations have started to recover. Also plant species richness in the margins of tilled fields tends to be (slightly but not significantly) higher in areas under REPS [17, 44].

3.13.3. Overall agri-environmental performance

Overall agriculture has been harmful to the environment but the pressure is easing. Declining livestock numbers and a reduction in the use of inorganic fertilisers (nitrogen

and phosphorus) and pesticides between 2000 and 2005, have helped to reduce water and air pollution pressures, the two key environmental problems for Irish agriculture since the early 1990s. Overgrazing by livestock in some areas, changes in land use (notably conversion of semi-natural grassland) and grassland management (the switch from hay to silage production), have also had adverse effects on soil quality and biodiversity but there have been recent improvements.

The agri-environmental information system does not effectively monitor and evaluate agri-environmental performance and policies, but this is changing [4, 6]. There is little information on farm management practices that affect either biodiversity [6, 17] or the environment (*e.g.* grazing practices, manure management) [14]. A well-established national water monitoring network, however, generates information related to agricultural impacts on water bodies. In addition, considerable effort is underway to upgrade the monitoring system, including: developing agri-environmental indicators [45]; the creation in 2006 of the National Biological Records Centre [17] together with Ag-biota a research project that includes the development of agri-biodiversity indicators [35]; and establishment of a national soils database in 2006 [46].

Agri-environmental policies have started to improve environmental performance since about 2000. This was reflected, in particular, in the strengthening of the REPS, with around 40% of farmers and farmland under the REPS by 2005. The scheme has provided some success in reducing nutrient pollution, but few local authorities are using the nutrient planning powers available to them under the *Water Pollution Act* [6, 22]. A survey of REPS and similar non-REPS farms in 2002, showed on average, lower use of inorganic and organic fertilisers on REPS farms [15, 21], although another survey found little difference in terms of beetle (*Carabidae*) species richness and abundance [44]. The REPS, however, has been criticised for its system of monitoring and evaluation and specific environmental targets are not well defined [17, 21, 38, 44, 47].

The projected contraction of agriculture should further reduce environmental pressure [6, 15, 18]. Projections indicate that in the period up to 2010-15 the decrease in grazing livestock numbers and fertiliser use would help lower nutrient pollution of water and air, while the trend toward further afforestation is likely to be beneficial for biodiversity and the sequestering of carbon. The European Court of Justice held in 2004 that Ireland was in contravention of the EU *Nitrates Directive,* for not having established an action programme (this was due to be established in December 1995) [11, 21]. An action programme is now in place, which should have a positive impact on water quality. Over 50% of national water bodies in 2004 were identified as being at risk or probably at risk of failing to meet the EU *Water Framework Directive* objectives by 2015. "At risk" does not imply that current water quality is impaired, but rather that there is a risk it may not meet the Directive's objective of "good status" in all waters by 2015 [17]. Although phosphorus surpluses have declined markedly, further reductions will be necessary to bring about a sustainable phosphorus balance and reduce eutrophication [6, 21].

Improved farm management and the use of best agricultural practices would ensure better control of agricultural water pollution, especially substantial investment in manure and slurry storage capacity [6, 17, 21]. This would also bring advantages in further reducing ammonia emissions, such as enabling the use of low emission manure spreading techniques [14]. In this regard a scheme introduced in 2006 to help farmers establish manure storage capacity and other facilities required by the *Nitrates Regulations*, attracted

almost 49 000 applications and should yield positive results. There are concerns that the rise in nitrate pollution of groundwater could become more widespread and require costly treatment of drinking water unless nutrient management plans are strengthened and implemented [26]. The implementation of the *National Action Programme*, under the EU *Nitrates Directive, EU Water Framework Directive* and cross compliance measures, should yield results in reducing agricultural nutrient pollution of water bodies [21, 22]. The *Nitrates Directive* derogation agreed by the EU for Ireland in November 2006 up to 2011, increasing the maximum limit of nitrogen from livestock manure from 170 to 250kg per hectare per year for grassland, will give time for graziers to adapt to the measures. This does not apply to pig and poultry producers.

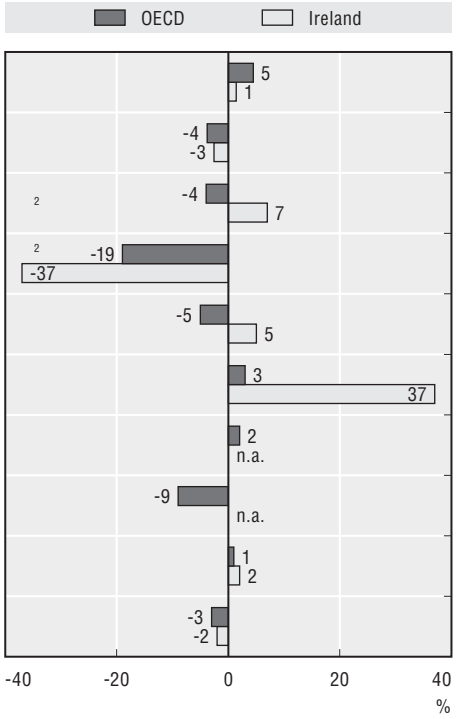
The REPS has had some recent success in addressing biodiversity concerns, but this has been mainly targeted at farmed habitats of high conservation value (*e.g.* peatlands, species rich grasslands) while large-scale intensive farms are significantly under-represented [17, 21, 38, 48]. The loss of farming in some upland and marginal areas could be to the detriment of semi-natural habitats and cultural farmed landscapes, including abandonment to shrub or conversion to forestry as already evident in the Burren (county Clare) [4]. This trend might continue into the future as projections suggest a 23% reduction in farm numbers between 2002 and 2015. By 2015 only a third of farms are projected to remain economically viable, with three quarters of these farms expected to be operated part-time [18].

The increase in part-time farming, however, could lead to greater biomass production through afforestation, with potential biodiversity and GHG emission reduction benefits [4, 18]. Under the Rural Development Regulation for the period 2007-13, aid for afforestation is provided up to a maximum of EUR 500 (USD 625) per hectare, on the condition that the tree plantings are compatible with environmental protection, such as water quality and landscape [8]. Fuel tax concessions for farmers undermine incentives to use energy more efficiently and may lead to higher GHG emissions. At the same time, the government has set a target for the agricultural sector to reduce methane emissions, equivalent to a 10% reduction in livestock numbers below business as usual 2010 projections.

The National Development Plan (2007-13) seeks to make the environment a central feature of farm budgetary support over the next seven years [49]. The focus is on reducing eutrophication, mitigating GHG and ammonia emissions, and enhancing biodiversity. The latter includes the purchase and restoration of areas of raised peat bogs, that also act as effective carbon sinks [49]. The overall package for agriculture under the Plan will be EUR 8.0 (USD 10.0) billion, an 85% increase over the expenditure during the last plan (2000-06). EUR 2.1 (USD 2.6) billion of this will be met from EU funding. The major share of expenditure, over EUR 6 (USD 7.5) billion, will be environmentally orientated, of which EUR 3 (USD 3.8) billion will be provided for REPS and related programmes, such as afforestation and farm waste management [49].

Figure 3.13.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

Variable	Unit		Ireland	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	101	104
Agricultural land area	000 hectares	1990-92 to 2002-04	–116	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	83	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	6	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	+111	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+82	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	n.a.	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	n.a.	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	+3	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–316	–30 462

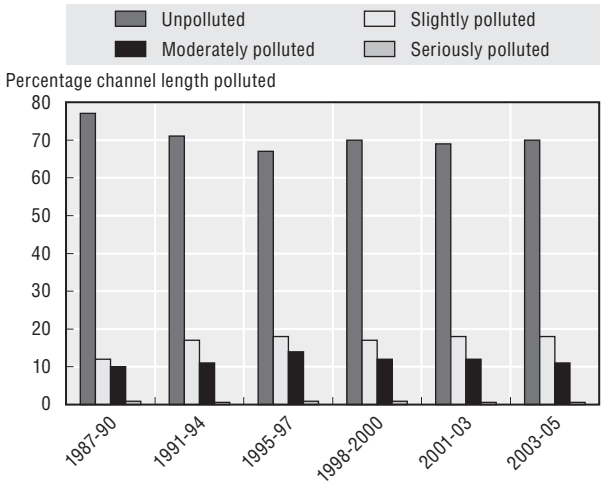
n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.13.3. **River water quality**

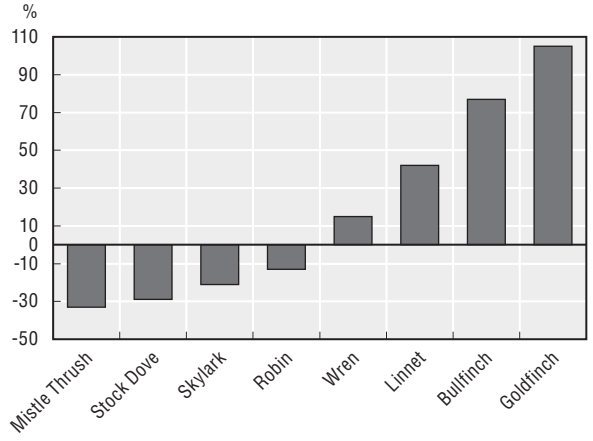
13 200 km channel length baseline



Source: Environmental Protection Agency.

Figure 3.13.4. **Population changes for key farmland bird populations**

1998 to 2004



Source: Countryside Bird Survey News, March, 2005.

StatLink http://dx.doi.org/10.1787/300472480286

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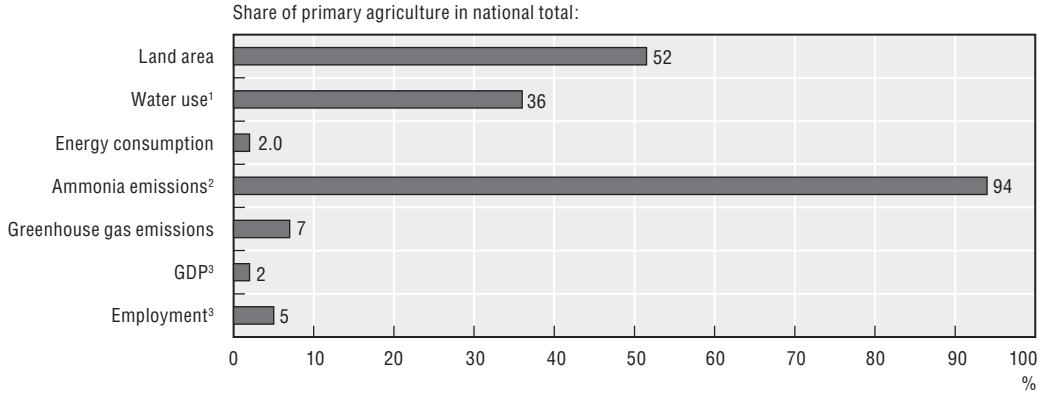
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3.14. ITALY

Figure 3.14.1. **National agri-environmental and economic profile, 2002-04: Italy**



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1. Data refer to the year 1999.
2. Data refer to the period 2001-03.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.14.1. Agricultural sector trends and policy context

Agriculture's role in the economy is small and decreasing, but more important in some regions. Farming contributes just over 2% of GDP, but nearly 5% of employment, although with marked regional differences, contributions rising in the South to over 4% of GDP and nearly 10% of employment [1, 2] (Figure 3.14.1).

Horticultural and permanent crops play a dominant role in the farming sector. Horticultural crops; olive groves; and grapes account for nearly 45% of total agricultural value, compared to 11% for cereals and almost 35% for livestock [1]. Horticultural and permanent crop production dominate in the South, with livestock and cereals more prominent in the North. While the total volume of agricultural production declined by 2% over the period 1990-92 to 2002-04, the trend in input use was more varied: pesticides rose by 8%; inorganic nitrogen fertilisers by 5%; and farm energy by 10%; although inorganic phosphorus fertiliser use declined by –26% (Figure 3.14.2). With the area farmed also declining by nearly 14% over this period, this suggests that the intensity of agricultural production has been increasing: both in terms of inputs used per unit volume of output; and per hectare.

Farming is mainly supported under the Common Agricultural Policy (CAP), with support also provided through national expenditure within the CAP framework. Support to EU agriculture has declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate). This compares to the OECD average

of 30% [3]. Nearly 70% of EU farm support is output and input linked, but this share was over 98% in the mid-1980s. Budgetary support to Italian farmers is currently over EUR 6 billion per annum of which 60% is funded by the EU.

Expenditure on agri-environmental programmes has risen substantially, accounting for 10% of total agricultural payments in 2002, of which over 80% were EU co-financed. Around 90% of these payments were provided to farmers in central and northern Italy, and 10% in the south. About 90% of payments were provided for conversion to organic farming; adoption of integrated farming; and grassland management [4]. Other measures aim to reduce erosion; limit water use; and enhance biodiversity conservation, such as through payments of EUR 202/head for endangered cattle species [5].

Agriculture is affected by a number of economy-wide environmental and taxation measures. The 1992 *Hunting Act* requires that 20-30% of agricultural and forest land should be devoted to fauna protection [6]. Water abstraction charges were introduced in 1994 under the *Galli Act* at very low rates for farmers of EUR 36/100 litres/second compared to EUR 1 550 for households and EUR 11 362 for industry in 2001; while subsidies are also provided for irrigation capital and operational costs [6] amounting to almost EUR 3.6 billion over the period 2000-05 [7]. A pesticide tax, introduced in 1999, is 2% of the retail price [6]; and a reduction of 22% of the full fuel tax is provided for agriculture and was equivalent to EUR 857 million in 2005 of budget revenue forgone [3], estimated to cut variable costs by about 14% [8]. Incentives for biofuels are provided, mainly for biodiesel, through exemptions on excise duties amounting to EUR 300 million over the period 2002-05 [9].

Farming is also affected by commitments under international environmental agreements, such as lowering ammonia emissions (*Gothenburg Protocol*) and methyl bromide use (*MontrealProtocol*), and addressing desertification (*UN Convention to Combat Desertification*).

3.14.2. Environmental performance of agriculture

With over 75% of mountainous land and a high population density, pressure on land is intense. Agriculture as the major land using activity accounted for 52% of land use in 2002-04, although the area farmed declined by nearly 14% between 1990-92 and 2002-04, the highest reduction among OECD countries (Figure 3.14.2) [1]. There are a wide variety of agri-ecosystems and landscapes ranging across Mediterranean, Alpine and Continental regimes [10].

Soil degradation is a major and widespread environmental problem, but there are no data to assess trends. About 70% of all land is subject to risk of accelerated *soil erosion* (over 5 t/ha/year) and about 12% is prone to high risk (over 10 t/ha/year) (Figure 3.14.3) [11, 12, 13, 14]. While soil erosion risks are exacerbated by a combination of climate and steep topography, erosion has also been aggravated by: poor adoption of soil conservation practices, notably, limited soil cover over the whole year, and less than 10% of arable land under conservation tillage [15]; monoculture cropping systems; and uncultivated land, notably conversion of cultivated mountain terraces to other uses [6]. *Soil compaction* risks have grown, mainly in Northern areas, such as the Po Valley, due to greater use of heavy farm machinery in wet conditions [16]. In the South and in the major islands about 5% of land is affected by *desertification*, including *soil salinisation*, associated with expanding olive cultivation on fragile land; excessive use of groundwater for their irrigation with the consequent intrusion of saline waters; and poor grove tillage practices [6, 17, 18]. Linked to these soil degradation problems, there has been a loss of *soil organic matter* (SOM), but efforts are being made to raise SOM levels so as to improve soil fertility and enhance soil carbon stocks, so helping to reduce greenhouse gas emissions [19].

Agriculture is both impacted by, and affects, the growing incidence of flooding and landslides. The increasing occurrence and severity of droughts, floods and associated landslides over the 1990s [16], are imposing a considerable human and economic cost [6, 20]. While summer storms and steep topography have led to flooding and landslides which adversely impact on farming, particularly in low lying plains, changes in farmland use have also had an effect. Although some hilly and mountainous land was ploughed in the 1970s/80s; over the 1990s certain areas reverted to shrub and low forest, which has helped increase water holding capacity [20]. However, the 16% decline in farm dams and ponds over the period 1985-2000, has reduced the water retention capacity of agricultural land [21].

Pressure from farming activities on water pollution has eased, but remains a problem. Rivers in the Po Valley are still polluted by different activities including agriculture, especially from livestock farms, while in the South eutrophication of reservoirs for drinking water has resulted from excessive fertiliser use [6]. Groundwater is the source of nearly 85% of drinking water, but about 25% of groundwater supply requires treatment before it is fit for drinking. Little progress has been made in reducing agricultural pollution of the Mediterranean, especially in the Northern Adriatic [6, 22].

The reduction in agricultural nutrient surpluses has lowered water pollution pressure. But absolute loadings of nutrients into water bodies remain high, contributing two-thirds of nitrates and one-third of phosphates delivered into rivers, and a major, but decreasing, share of pollution of groundwater, while efficiency of nutrient use is low [6, 23, 24]. Much of the reduction in nutrient surpluses was related to declining livestock numbers and low animal stocking densities compared to the EU15 average, while restrictions on manure spreading in the Po Valley have also had an impact (Figure 3.14.2) [2, 23]. In addition, the volume of inorganic phosphorus fertiliser use declined by –26% between 1990-92 and 2002-04, although nitrogen fertiliser rose by 5% over the same period, while the use of sewage sludge has risen nearly 4 fold between 1995 and 2000 [15]. The decrease in phosphate use is partly due to the switch in area payments, plus an improvement in fertiliser use efficiency and management, with crop production volume declining over this period by nearly 3%, and an increasing number of farms adopting a fertiliser management plan, the proportion rising to 31% of farms by 2000 [2]. But nutrient surpluses vary considerably by region [2] with some Northern regions (Lombardy) having surpluses twelve times greater than in the South (Basilicata) [23], reflecting the greater surpluses from livestock and maize production in the North [24].

With the increase in pesticide use pressure on water bodies persists (Figure 3.14.2). Rising levels of pesticides in groundwater could reflect delayed response times between application and detection [6, 23]. In a survey in Northern Italy in 1999-2000 the herbicide atrazine was present in all the groundwater sites surveyed, and in 30% of the sites was above the maximum admissible concentration, despite the ban on the sale of the herbicide since 1986 [25]. Around 2% of fruit and vegetable samples in 2003 had residual pesticides above national standards [1]. There are signs, however, that the pressure on water pollution from pesticides could be easing with the adoption of specifically targeted pesticides and the expansion in organic production [1, 2]. Adoption of low dosage pesticides may reduce human and environmental risks. ***Organic farming*** accounted for around 7% of farmland (2002-04), with nearly 60% of this area in the south, expanding rapidly during the 1990s to over 20% of the EU15 organic area [1, 2, 6, 26].

While agricultural water use has been stable, rates of groundwater abstraction are a concern. Agriculture's share in total water use is about 60%, reflecting the prominent role of irrigation, with two-thirds of water drawn from surface water [2, 7, 27, 28, 29]. About 50% of the value of agricultural production and 60% of farm exports are derived from irrigated farming [29, 30]. The area under irrigation remained unchanged between 1990-92 and 2001-03 and accounted for 17% of farmland by 2001-03, mostly concentrated in drier Southern regions which account for over 60% of the irrigated area [1, 2, 27]. Excessive extraction of groundwater for irrigation occurs in the South (often illegally) which, coupled with high losses through leakage, has led to water shortages over at least 3 months of every year [6, 18, 27, 29]. Estimated water losses across the national irrigation network are 30-50% of water withdrawals. This is due to both poor infrastructure maintenance and inadequate technology [7]. Nevertheless, there are indications of improvements in irrigation water management toward using more efficient water application technologies, such as drip emitters (used on over 20% of the total irrigated area in 2000) [2, 7].

Overall air pollutant emissions from farming have been declining since 1990. Agriculture's share in total ***ammonia emissions*** was 94% in 2003-05, mainly from livestock, with emissions declining by 9% between 1990-92 and 2001-03 (Figure 3.14.2), with a further 4% decline in emissions between 2002 and 2004. To meet Italy's ammonia emission commitments for 2010 agreed under the *Gothenburg Protocol*, total ammonia emissions will need to be reduced by 6% from their 2001-03 level, although in 2005 total emissions were for the first time below the 2010 target. In 1996 Italy used about 13% of the world's ***methyl bromide***, but between 1994 and 2001 usage was reduced by over 40% to about 3 900 tonnes. Methyl bromide is used almost entirely in the horticultural sector (mainly tomatoes, eggplants, melons, strawberries and flowers), with nearly 90% used in Sicily, Lazio and Campania [6, 31, 32]. Between 2005 and 2008 "Critical Use Exemption" (CUE), which under the *Montreal Protocol* allows farmers additional time to find substitutes, is being reduced from 1 379 tonnes (ozone depleting potential) to zero.

Agricultural emissions of greenhouse gases declined by 7% between 1990-92 and 2002-04, accounting for 7% of national emissions (Figure 3.14.2). This compares to a 12% rise in total GHG emissions across the economy and a commitment under the *Kyoto Protocol* to reduce total emissions by 6.5 % up to 2008-12 under the *EU Burden Sharing Agreement*. An 11% increase in greenhouse (GHG) emissions from farm fuel combustion was offset by emission reductions of 3% for livestock and 1% for crops (CO_2 equivalents) [33], but a reduction in emissions is projected to 2010 [34]. The rise in fuel combustion is largely explained by the 14% growth in the number of farm machines (tractors, combine harvesters) over the period 1990-92 to 2001-03 [35], but also the requirement for field spreading of manure and the expansion in organic production requiring more mechanical weeding. While ***carbon storage*** has increased with farmland converted to forest use, the ploughing of pasture for arable use together with soil degradation has led to a reduction in soil organic matter and soil organic carbon [33]. Agricultural ***biomass production*** for fuel and energy has expanded slowly, but would need to double every year from 1997 to meet Italy's renewable electricity generation target by 2010 [9].

Adverse impacts on biodiversity from farming activities continue, although the lack of monitoring data makes a precise assessment difficult [10, 36]. Overall agricultural land use changes since 1990 have been detrimental for biodiversity, with a reduction in semi-natural farmed habitats, including the conversion of permanent pastures and meadows to commercial forestry and crop production (Figure 3.14.3) [37]. Some permanent pasture areas, such as in the

Po valley which were established in the 19th century, have a much higher level of plant species diversity than in surrounding cultivated areas [38]. The conversion of marginal mountain farmland to other land uses has also adversely impacted the richness and abundance of open country bird species, flora and cultural landscapes [39]. The drainage of wetlands continues although at a lower rate over the period 1990 to 2004 compared to earlier decades [10]. The area under agri-environmental schemes devoted to biodiversity conservation as a share of the total farmland was 1% in 2001 compared to the EU15 average of 12% [36]. Some areas under these schemes have been beneficial to bird conservation [40], while the *Hunting Act* requires 20-30% of farm and forestry land to be devoted to fauna protection.

There has also been loss, and endangerment, of local crop and livestock species. With respect to livestock, Italy has amongst the highest number of endangered breeds across the EU15 [41], and amongst the greatest number of endangered breeds under conservation schemes in the EU [15]. *In situ* and *ex situ* conservation is being undertaken for livestock [6, 21, 36, 41], and to a lesser extent for crops [21, 42].

3.14.3. Overall agri-environmental performance

The key agri-environmental problems facing Italy are soil erosion and water pollution. Other, lesser challenges include: improving energy use and water use efficiency; biodiversity and landscape conservation; and desertification poses a problem in the south, especially in Sicily and Sardinia.

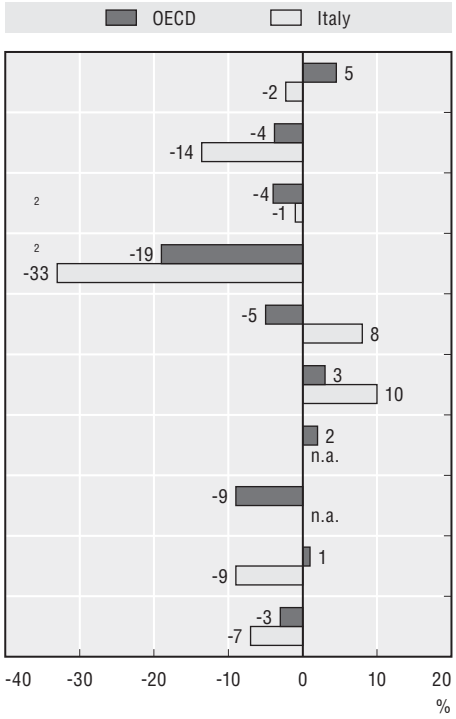
Adverse environmental impacts from agriculture persist, but some positive trends are emerging. Reduction in nutrient surpluses, together with declining pesticide use, has helped ease pressure from agriculture on water quality. But water pollution from agriculture remains a key issue as it generates the major share of nutrient pollution, with absolute loadings high and the rapid increase in use of sewage sludge raising concerns of heavy metal pollution. Water use and air emissions from agriculture, both methyl bromide (an ozone depleting substance) and greenhouse gases, have decreased since 1990. For ammonia while emissions rose slightly between 1990-92 to 2001-03, they declined between 2002 and 2004. There is some evidence to suggest that the risk of soil erosion persists across a major part of cultivated land, while poor soil and irrigation management practices have aggravated problems of compaction, salinisation and loss of soil organic matter. Some improvement in biodiversity conservation is evident, reducing risks, particularly, of genetic erosion of local livestock breeds. Even so, the continued conversion of semi-natural agricultural areas, mainly to annual crops and forestry, has had an adverse impact on flora and fauna.

Monitoring and evaluation of agri-environmental trends is being improved but many gaps remain. Only a few Italian regions have established a monitoring strategy to track agri-environmental impacts and evaluate agri-environmental programmes [4]. National and sub-national monitoring systems are poorly developed across a number of key agri-environmental concerns [6], including agriculture's impact on soil and water quality, water use, biodiversity and landscape. But initiatives are underway to improve monitoring systems, such as the development of soil monitoring networks [43], and recently the National Institute of Agricultural Economics (INEA) published a national report, periodically updated, measuring the progress of agriculture toward sustainability [2].

Changes to policies may enhance environmental performance but problems continue. New provisions under Agenda 2000 and the 2003 CAP reforms will involve, from 2005/06, the use of cross compliance targeted at farming practices intended to benefit the environment. The area enrolled under agri-environmental measures, however, was little more than 20% of the total agricultural area and less than half the EU15 average in 2002 [2, 15]. Water charges are at rates which act as a disincentive to water conservation, with a large gap between farm charges and the cost of water supply, as apparent in the excessive extraction of groundwater for irrigation in areas of water shortage. Fuel tax concessions for farmers undermine more efficient use of energy. Direct farm energy consumption has grown at 10% over the period 1990-92 to 2002-04 compared to a reduction in the volume of farm production by 2%.

Figure 3.14.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

Variable	Unit		Italy	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	98	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–2 390	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	39	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	11	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	+6 075	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+315	+1 997
Agricultural water use	Million m^3	2001-03	+20 140	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	7.7	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–43	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–2 929	–30 462

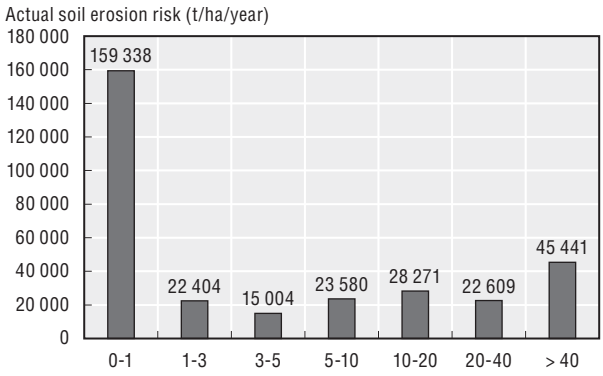
n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

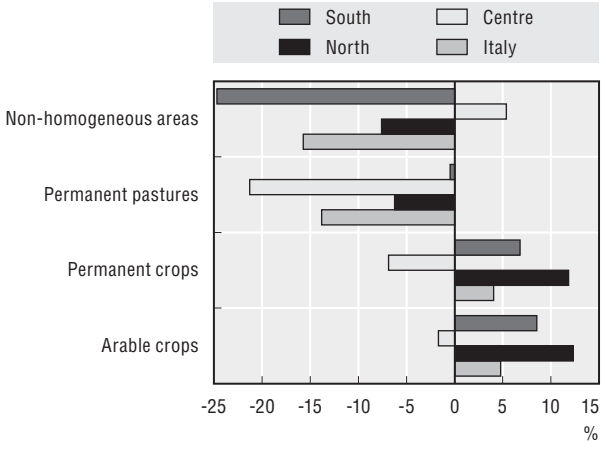
Figure 3.14.3. **Actual soil water erosion risk**

Km^2 of the Italian land by soil erosion classes, 1999



Source: P. Bazzoffi based on Von der Knijff, J.M., R.J.A Jones and L. Montanarelle (1999), *Soil Erosion Risk Assessment in Italy*, Joint Research Center, European Commision, Ispra, Italy.

Figure 3.14.4. **Regional change in agricultural land area: 1990 to 2000**



Source: APAT Environmental Data Yearbook, 2004 edition.

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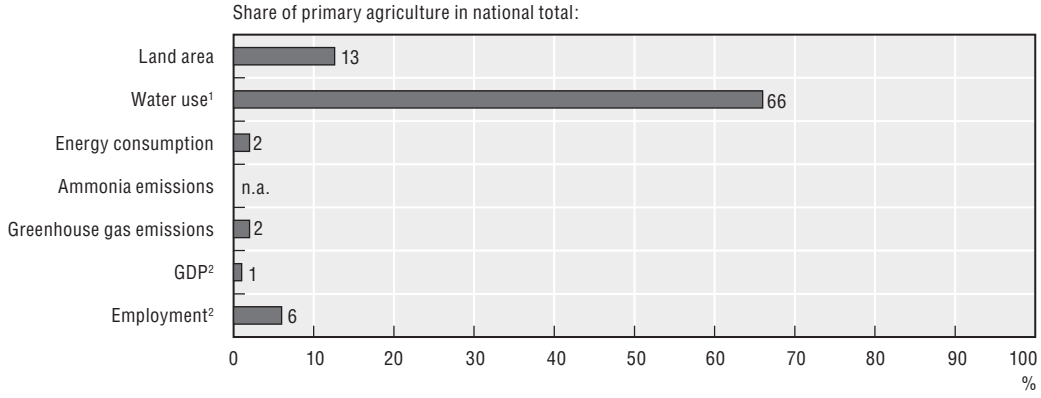
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3.15. JAPAN

Figure 3.15.1. **National agri-environmental and economic profile, 2002-04: Japan**



StatLink http://dx.doi.org/10.1787/300560776606

1. Data refer to the year 2001.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.15.1. Agricultural sector trends and policy context

Agriculture's contribution to the economy is small. The agricultural sector currently accounts for about 1% of GDP and 6% of employment [1] (Figure 3.15.1). With a high GDP per capita and one of the most densely populated countries in the OECD, Japan is a major net importer of agricultural products.

Rice accounts for 55% of total agricultural land providing 25% of gross farm output value. Horticultural and arable crops account for 68% of farm output value with livestock providing a further 28%. Average farm size is less than 2 hectares, small relative to other OECD countries, and agricultural income accounts for only around 13% of total farm household income [2]. Agriculture makes intensive use of purchased inputs by OECD standards, but the total volume of farm production and farm inputs between 1990-92 to 2002-04 has decreased (Figure 3.15.2). Use of inorganic fertilisers has declined by –18% for nitrogen fertilisers and by –27% for phosphorus fertilisers; pesticide use declined by –27%; on-farm energy use by –5%; water use by –3%, while the volume of farm production also decreased by –11%, mainly due to lower crop production –17%, compared to the reduction in livestock –6% [1].

Agricultural support is almost twice the OECD average. Support (as measured by the OECD's Producer Support Estimate) has changed little, declining from 64% of farm receipts in the mid-1980s to 58% in 2002-04, compared to the OECD average of 30%. Almost all support (90%) is output and input linked, and primarily provided through administered prices, supply control and trade measures, with the rate of support highest for rice, cereals, and dairy products [3].

Japan provides budgetary payments to address agri-environmental issues. Expenditure on agri-environmental programmes more than doubled over the 1990s, but representing 10% of total payments to farmers. Adoption of sustainable agricultural practices is encouraged by concessionary loans, tax relief to farmers to help reduce chemical fertiliser and synthetic chemical pesticide use, and also a mandatory code of practice for pesticide application. Direct payments to farmers in hilly and mountainous areas aim to prevent abandonment of farming and maintain a range of ecosystem services associated with farming in these areas. Tax exemptions, low-interest loans, regulatory standards and other policy instruments are also used to address agri-environmental issues. In 1999 regulatory standards for manure management were established under the law concerning *Appropriate Treatment and Promotion of Utilisation of Livestock Manure* [4]. National and local governments finance facilities that recycle farm waste, such as manure, and in some cases set targets to reduce farm nutrient pollution of water [5].

Agri-environmental linkages are impacted by economy wide and taxation measures, as well as international environmental agreements. Regulations under the 1970 *Water Pollution Control Law* set upper limits for agricultural pollution, such as from pig and cattle units, and the 1972 *Offensive Odour Control Law* covers livestock. The River Act controls the withdrawal of water from rivers so as to maintain a downstream minimum flow for the conservation of aquatic ecosystems [6]. Farmers, and some other users, are exempt from fuel taxes equivalent to around JPN 3 billion (USD 26 million) in 2006 [3, 5, 7]. Irrigation and drainage infrastructure is part-financed by farmers and from national and local governments budgets [5, 8]. Around JPN 345 (USD 3.1) billion of irrigation finance was from national government annually between 2002 and 2006 [3]. Irrigation systems are managed by *Land Improvement Districts* (LIDs) which are voluntary community-based organisations with the purpose of undertaking the construction, improvement and management of irrigation/drainage facilities and farmland improvement including farm consolidation, with 7 000 LIDs managing on average 500 hectares in 2000 [8, 9, 10]. The *Land Improvement Law* was amended in 2001, such that part government financed projects, for example, irrigation and drainage infrastructure, are implemented with consideration for their impact on biodiversity, while some local governments have also introduced programmes to protect biodiversity on farmland (*e.g.* Hyogo Prefecture's conservation of Oriental White Storks, *Ciconia boyciana* [11]). Agriculture is also impacted under international environmental agreements including commitments to lower: methyl bromide use (*Montreal Protocol*) and greenhouse gases (*Kyoto Protocol*).

3.15.2. Environmental performance of agriculture

The key agri-environmental challenges relate to pressure on water quality and natural resources, and enhancement of the sector's capacity to provide ecosystem services. The relatively high intensity of farm production has led to water pollution. Changes in farmland use have increased pressure to improve natural resource management, especially flood and landslide mitigation, and biodiversity. Some other agri-environmental issues are also significant including soil erosion, water use in certain areas, and air emissions.

Over 70% of land is mountainous, and with a high population density pressure on land is intense. Agriculture accounted for 13% of the total land area in 2002-04, down from 16% in the early 1990s. Because of the dominance of paddy rice cultivation, agriculture accounts for 66% of total water use [8]. Farming operates across a diverse range of climates, but many regions are in the Asian monsoonal zone favourable to rice production with abundant

precipitation. Precipitation varies greatly by year, season and region, with floods occurring in many areas and water shortages in some regions [12]. Heavy rain and steep topography have caused frequent floods and landslides in many areas at considerable human and economic cost [5].

Soil erosion is not a widespread problem, but is of concern in certain regions [13], with about 40% of farmland situated in river basins where gradients are steep [14]. Many watersheds are interspersed by forested land and paddy fields which limit sediment discharge. But soil erosion is a concern in some areas, although soil conservation measures are being developed to address these concerns [13]. The risk of increased erosion rates is possible if trends in the abandonment of farming in hill areas continue, especially paddy fields, although there is currently little data to analyse soil erosion trends.

Water pollution originating from agricultural nutrients remains a key challenge [5]. The water quality (eutrophication) of lakes and coastal areas has shown no significant improvement, but there is little information on agriculture's share in nutrient loadings of water bodies [5]. Indirect evidence shows that farm nitrogen and phosphorus surpluses have declined over the period 1990-92 to 2002-04, but absolute levels per hectare remain among the highest across OECD countries, for both nitrogen and phosphorus (Figure 3.15.2). Similarly the very high accumulation of surplus phosphorus in farmed soils raises the likely future risk of eutrophication of water in view of the long time lags in involved in phosphorus transport through soils [15]. Despite a reduction in phosphorus surplus over the past 15 years, Japan has the highest intensity of phosphorus surplus per hectare of agricultural land across OECD countries, nearly 5 times above the OECD average (Figure 3.15.2).

Farming is one of the major sources of nitrate contamination of groundwater in certain areas [16, 17,], with 5% of wells exceeding the environmental quality standard in 1999 [18]. There are also concerns of water contamination from livestock pathogens, including livestock hormones and certain pesticides acting as an endocrine-disruptor to human and wildlife reproductive systems in aquatic ecosystems, but these were detected in only limited samples at low concentrations in a nationwide survey from 1999 to 2000 [19, 20]. Farming is also identified as a source of pollution (eutrophication) leading to "red tides", algal blooms, with adverse impacts on marine life [21].

The horticultural and livestock sectors are the origin of most agricultural nutrient pollution. Overall fertiliser use declined since 1990, mainly because of the decrease in rice production. Rice production accounts for about a third of the total volume of inorganic fertiliser use but it is applied at a lower rate per hectare on paddy fields than for horticultural crops [15, 22]. Nitrogen leaching into surface water and groundwater from paddy fields is low compared to vegetable fields and orchards, due mainly to the low rate of fertilisation and partly to denitrification, a process characteristic of submerged soils [16, 18, 23]. Although denitrification does lead to the release of nitrous oxide, that is a powerful greenhouse gas, the amounts are very small compared to the amounts released from dry land farming. Moreover, for paddy field watersheds using a recycling irrigation system (although the area and number is unknown) this lowers nutrient pollution [24, 25, 26].

While production of livestock has declined over the last decade, there has been a trend towards larger operating units, especially for pigs and dairy cows [4, 27], leading to increased localised levels of livestock effluents [15, 23, 28]. However, there has recently been an increase in the number of livestock farms equipped with manure treatment facilities,

rising from 5 000 to 6 000 farms between 2000 and 2003, reaching nearly 90% of the government's target for this period [29]. But the number of farms under nutrient management plans was only 20% in 2000-03, and the efficiency of nutrient use efficiency (output/input) is among the lowest across OECD countries.

The pressure on water pollution from pesticides has eased, with a 27% reduction in pesticide use between 1990 and 2003 (Figure 3.15.2). The decrease in pesticide use over this period was most likely associated with the 19% reduction in the volume of crop production and to a limited extent the expansion in the number of farmers adopting environmentally beneficial practices, including organic farms. The intensity of pesticide use, however, remains high by OECD standards, due in part to the pressure on land and labour and to the humid temperate climate [5]. Incidents of human poisoning from pesticides have been reduced drastically since the 1960s [5], and recent national monitoring data for surface water (river, lakes and coastal areas) reveals that the number of samples above national drinking water standards for pesticides was less than 0.1% [30].

Some regions are experiencing water shortages leading to growing competition for water resources. For regions where competition for water resources is intensifying this is exacerbated by the frequent incidence of water shortages in recent years [4, 19], although shortages can be addressed through voluntary and regulatory reallocation of water [31, 32]. Projections suggest that demand for irrigation water for dryland crop production may expand [33]. Given that agriculture is the major user of water resources, including a 31% share in national use of groundwater in 2002 [1, 8], reducing future pressure on the demand for water will in part depend on promoting the efficient use of water by agriculture [4]. Even so, agricultural water use declined by 3% between 1990-92 and 2001-03 (Figure 3.15.2).

Air pollution linked to farming has declined over the period since 1990. With about 80% of agricultural ***ammonia emissions*** accounted for by livestock, the decrease in livestock production, as well as fertiliser use, suggests emissions have also declined, but they are not regularly monitored [34]. Since the 1970s the number of complaints related to offensive livestock odours has significantly declined [38]. For ***methyl bromide*** use (an ozone depleting substance) Japan is a major OECD user and reduced its use by over 70% by 2003, as agreed by the phase-out schedule under the *Montreal Protocol*, which seeks to eliminate all use by 2005. In 2005 "*Critical Use Exemption*" (CUE), which allows farmers additional time to find substitutes, was agreed up to 449 tonnes (ozone depleting potential) under the *Protocol*. Growers of melons, peppers, watermelons and field ginger account for over 80% of the 2005 CUE quantity [36].

Agricultural greenhouse gases (GHGs), declined by14% between 1990 and 2004, accounting for 2% of total GHGs (2002-04) [37]. This compares to an increase in GHG emissions for the economy as a whole of 10% over the same period relative to a *Kyoto Protocol* target agreed by Japan to reduce total emissions by 6% in the commitment period from 2008 to 2012. Much of the reduction in agricultural GHGs has been due to lower methane and nitrous oxide emissions following the decrease in rice production, fertiliser use and livestock numbers [40]. The reduction in ***direct on-farm energy consumption*** by 5% between 1990 and 2004 has also played a role in lowering GHG emissions, while ***carbon sequestration*** may have risen where farmland was converted to forest or other vegetative growth.

The decline in farmland is reducing agriculture's capacity to provide ecosystem services. Agriculture can supply certain ecosystem services depending on their management, and

according to Japanese research rice paddy fields provide a higher level of ecosystem service than other land use types [32]. But due to the decrease in the area farmed by 9% between 1990-92 and 2002-04, especially the 17% reduction in the paddy field area, provision of these ecosystem services has been impaired. For example, agricultural water retaining capacity declined by around 15% from 1990-92 to 2000-02 (Figure 3.15.3) [1]. Consequently soil erosion and flooding risks increased [5]. Farmland accounts for 20% of the area classified as a landslide hazard zone, consequently landslide risks are low on farmland. Research in Japan indicates that the rate of landslide occurrence is 3 to 4 times higher on abandoned farmland than on cultivated land [5, 38]. In addition, in some areas agriculture's groundwater recharge capacity has decreased with the reduction in the paddy rice area [6, 31].

Agricultural land reclamation and intensification have adversely impacted biodiversity. Despite the net reduction of agricultural land area, the reclamation of wetlands and tidal flats for farming has led to substantial losses and deterioration of certain habitats over the past 20 years [5, 39]. Conversion of land from other uses to agriculture continues but has declined from over 10 000 to 4 000 hectares/annum over the past decade [1]. Agricultural pollution of some water bodies is also harming aquatic habitats [5, 39]. Modernisation of some paddy systems, including lining waterways and ponds with concrete, field consolidation, and removing field interconnections, has reduced the abundance of aquatic species and the birds that feed on them [40, 41, 42].

The conversion of agricultural land to other uses is a threat to certain wild species. The net reduction in farmland over the 1990s has been converted to transport infrastructure, urban use, forest and left to revert to a "natural" state [1]. Some farming systems and rural landscapes, notably less intensive rice paddy fields and traditional "Satochi" landscapes [39] (these contain a mix of habitats *e.g.* forests, paddy fields, dryland crops, and orchards), provide key habitats for flora and fauna [40, 41, 44], hence their loss is of concern for the conservation of wildlife species. But the extent and changes in the area of "Satochi" landscapes is unclear. Based on a 2003 Ministry of Agriculture survey of paddy fields, they were found to provide habitat for one-third of total fresh water fish species and dragonflies, a quarter of reptiles and amphibians, about one-fifth of birds and 14% of plants [6, 31, 40]. Moreover, a major share of endangered species are also found in paddy fields. But where farmland is converted to forest or left to a "natural" state, the overall impact on biodiversity is unknown [40].

Reduction in agricultural land area is considered to impair the value of landscapes. The Agency for Cultural Affairs estimates that over 90% of national cultural assets are closely related to agriculture or rural activities [1], although the extent to which the value of these assets are being reduced with the decrease in farmland is unknown. There is evidence of a greater homogeneity of "Satochi" landscapes mainly because of agricultural intensification [43], but there are little data available to monitor the process [45].

3.15.3. Overall agri-environmental performance

Overall pressure on the environment has been reduced with the contraction of agriculture. But the reduction in agricultural activity has also reduced the sector's capacity to provide ecosystem services. Projections suggest that the contraction of agriculture is set to continue over the next 10 years, which will lower the pressure on the environment [46]. The decrease in the area farmed and uptake of sustainable farming practices has led to lower fertiliser and pesticide use and greenhouse gas emissions. With the more moderate

reduction in livestock and horticultural production, however, plus further intensification and enlargement of production units this has been a major source of water and air pollution in some regions.

The intensity of pesticide and fertiliser use and nutrient surpluses are high by average OECD standards [5], while the share of farms under nutrient management plans is low and nutrient use efficiency among the lowest across OECD countries. Farmer exemption from energy and fuel taxes can act as a disincentive to use energy and fuel efficiently. Efforts to limit agricultural water pollution have been slow compared to controlling pollution from industrial and urban sources [5]. The decrease in farmland has reduced the sector's capacity to provide a range of ecosystem services, especially flood and landslide mitigation, groundwater recharge and biodiversity conservation.

The lack of monitoring data impairs evaluation of Japan's agri-environmental performance. Water quality of rivers, lakes, coasts, and groundwater throughout Japan, which includes those in agricultural zones has been monitored for more than 30 years, but since farmland and non-farmland are intermingled, the agricultural sector's share in water pollution has not been identified precisely. In addition, monitoring data are also lacking for soil erosion and ammonia emissions, but recent initiatives are beginning to address this deficiency [47]. Little is known of the relative costs and benefits of using agricultural land to provide ecosystem services, especially paddy rice fields, compared to other land use types.

Recent policy initiatives strengthen existing agri-environmental programmes. *Principles of the Environmental Policy in Agriculture, Forestry and Fisheries* (2003), provides a new framework for agri-environmental policies, with a shift to cross compliance measures targeted to environmental beneficial practices, more clearly defined policy goals and provision of a policy evaluation framework [3, 47]. The *Biomass Nippon Strategy* (2006) establishes a set of programmes aimed at recycling more than 80% of biomass waste (which includes livestock manure) and utilisation of more than 25% of unused biomass (carbon equivalent terms) by 2010 [29, 48]. The development of social structures, such as water user associations involves all stakeholders, not just farmers, in addressing environmental issues [49, 50], and is being strengthened through the 2005 *Basic Plan for Food, Agriculture and Rural Areas*, which also aims to further advance environmental objectives in agricultural policies [51].

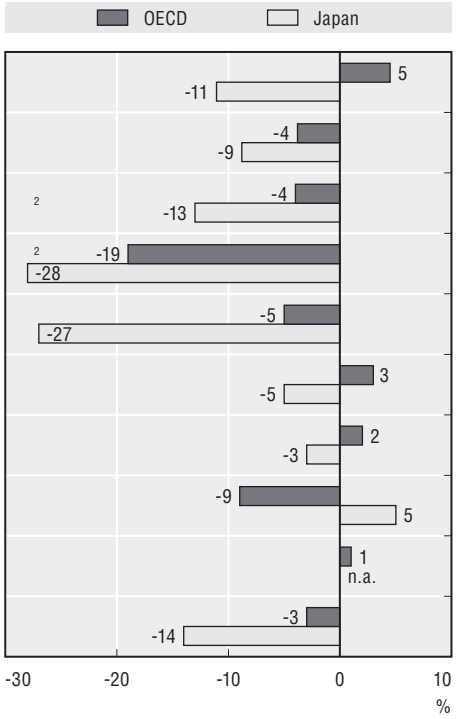
A number of recent measures are aiming to address climate change in agriculture. The *Strategy for Preventing Global Warming* (2007) focuses on measures for mitigation, adaptation and international co-operation [52]. Concerning mitigation the *Strategy* includes measures such as, *Forest Sink*, *Utilisation of Biomass*, and the *Voluntary Action Plan of the Food Industry*, which are to be accelerated. The government's *Boosting the Production of Biofuel in Japan* (2007) sets a goal for producing 50 000 kl of biofuel domestically per annum by 2011, and in the mid-to long-term aiming to significantly increase production of biofuel in Japan, utilising cellulose materials compatible with food production [53]. Regarding adaptation measures, studies on the damage to agricultural production due to global warming have been completed, such as the *Report on adaptation measures by items and the roadmap*. For international co-operation this will be promoted based on mitigation and adaptation technologies.

The Strategy for Biodiversity Conservation (2007) is being developed as guidelines to promote biodiversity conservation in the agriculture, forestry and fisheries sectors [54]. These guidelines take into account that agriculture, forestry and fisheries are essential activities that provide food and raw materials as well as habitats for many species, utilizing natural cyclical functions. For example, some endangered birds are under rehabilitation on agricultural land.

There are also signs that more farmers are adopting sustainable practices [14, 55], as the number of "Eco-farmers" (farmers whose sustainable farming plan is certified by the prefectural government) had increased to some 127 000 by March 2007, or about 7% of all farms (Figure 3.15.4). But these positive developments in agri-environmental policy evolution have to be evaluated in the context of high output-related farm support measures [3].

Figure 3.15.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

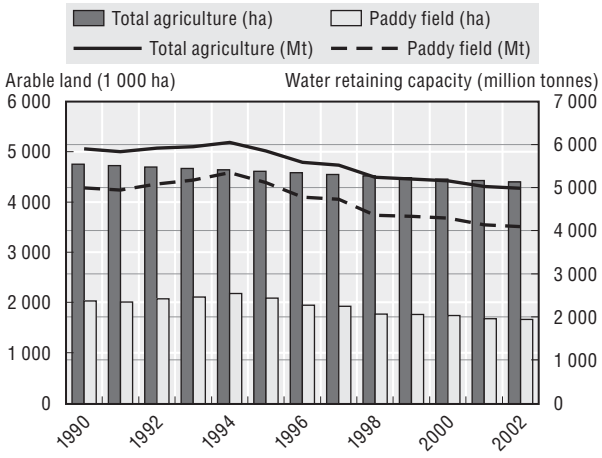
Variable	Unit		Japan	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	89	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–457	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	171	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	51	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–23 900	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–339	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–1 790	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	21.3	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	n.a.	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–4 611	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

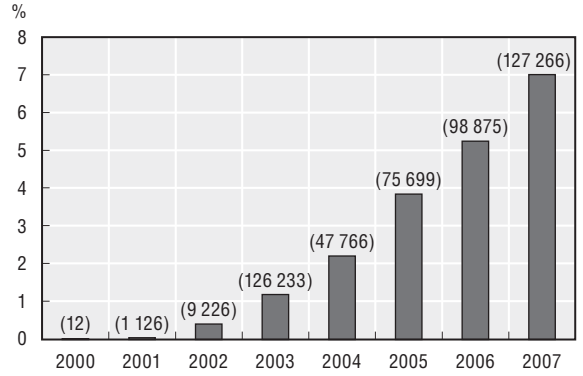
Figure 3.15.3. **National water retaining capacity of agriculture**



Source: Ministry of Agriculture, Forestry and Fisheries, Japan.

Figure 3.15.4. **Share of eco-farmers in the total number of farmers**

As a % of the total number of farmers



() Number of eco-farmers.

"Eco-farmers" are certified by a governor as environmentally-friendly farmers. The obligation of eco-farmers is to make a plan to introduce techniques for using compost for soil conditioning and reducing the use of agricultural chemicals based on the Law for Promoting the Introduction of Sustainable Agricultural Practices.

Source: Ministry of Agriculture, Forestry and Fisheries, Japan.

StatLink http://dx.doi.org/10.1787/300566438140

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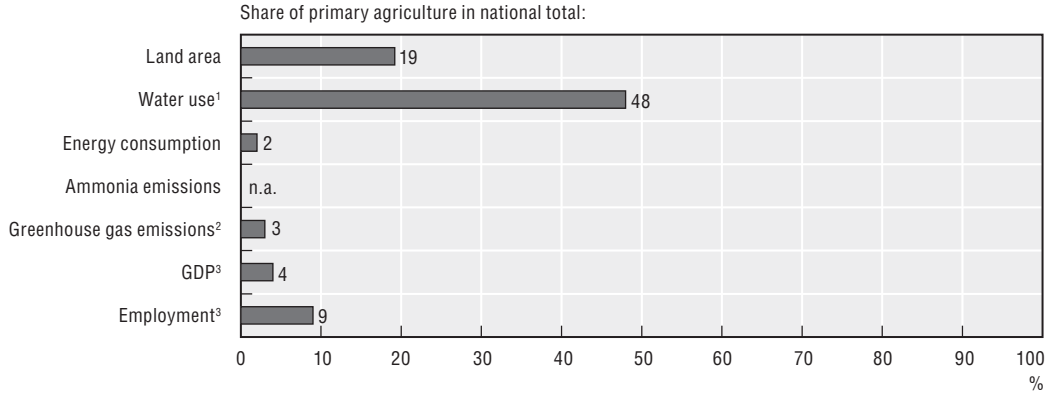
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3.16. KOREA

Figure 3.16.1. **National agri-environmental and economic profile, 2002-04: Korea**



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1. Data refer to the year 2002.
2. Data refer to the period 1999-01.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.16.1. Agricultural sector trends and policy context

Despite the rapid growth in agricultural production, the acceleration of the Korean economy as a whole has resulted in a decline in the importance of agriculture [1]. Agriculture now accounts for around 4% of GDP and 9% of employment compared to respective figures of 8% and 16% in 1990, while the country is a growing net importer of agricultural products (Figure 3.16.1).

Farming is dominated by rice. The crop accounts for 40% of gross farm receipts and 60% of the total agricultural land area, but livestock, especially pigs and poultry, and fruit and vegetables, are becoming more important [2]. Average farm size is extremely small by OECD standards, less than 1.5 hectares, with a narrow spread around this average. As land and labour are scarce, agriculture makes intensive use of purchased inputs and farm machinery. The use of the latter showed the largest increase, over 180%, across OECD countries between 1990-92 and 2001-03, and has led to a 43% rise in direct on-farm energy consumption (Figure 3.16.2). This compares to an almost 40% reduction in farm employment. There are signs that the intensity of production diminished over the period 1990-92 to 2002-04 with a nearly 7% rise in the volume of farm production: 49% for livestock and 5% for crops. Over the same period the volume of inorganic fertiliser use has declined by –22% for nitrogen fertiliser and –33% for phosphate fertiliser, and pesticide use reduced by –8%, but for water use there was an increase of 7% over this period (Figure 3.16.2).

Support to the agricultural sector is amongst the highest across OECD countries. Support has declined from 70% of farm receipts in the mid-1980s to 63% in 2002-04 (as measured by

the OECD's Producer Support Estimate) compared to the OECD average of 30%. Nearly all farm support (93%) is output and input linked, with policies dominated by market price support implemented through trade measures and domestic price stabilisation. Support is focussed on rice, but recent policy priorities have been widened to address environmental, food quality and safety, and rural development issues [3].

"The Agro-Environmental Policy towards the 21st Century" was launched in 1996 to address environmental issues in agriculture. The initiative seeks to limit harmful impacts of agriculture on the environment and encourage wider use of practices which can reduce environmental pressure, such as Integrated Pest and Nutrient Management and organic farming [4]. Although fertiliser and pesticide inputs are subsidised [5, 6], since 1997 pesticides have been subject to an environmental charge per container of KRW 6 (USD 0.006) (less than 500 ml) to KRW 16 (USD 0.014) (more than 500 ml); while an emission charge on excess livestock pollution has applied since 1991 of KRW 74 (USD 0.06) per cubic metre of waste [5]. Cross compliance and direct payments have been implemented to reinforce existing agri-environmental measures. The *Direct Income Support for Paddy Field* programme provides cross-compliance payments for paddy fields paid on a per hectare basis of between KRW 432 000 and KRW 532 000 (USD 375 and USD 462) per hectare annually, with a programme budget of KRW 481 billion (USD 417 million) in 2004. Payments are conditional on farmers reducing the use of fertilisers and pesticides.

Since 1999 Direct Payments for Environmentally Friendly Farming were introduced, to restrict the use of fertilisers and pesticides in drinking water conservation areas; and also for soil conservation practices. The measure was broadened in 2002 by making payments available nationally, with eligibility based on the amount of chemicals used and, in the case of soil conservation practices, according to local soil fertility and climatic conditions [7]. Expenditure on the programme increased from KRW 3 to 4.5 billion (USD 2.5-4 million) from 2003 to 2004 [3]. From 2003, farmers who set aside rice fields for three consecutive years may receive KRW 2 185 000 (USD 2 600) annually. Under 3% (27 000 hectares) of paddy fields have been set aside so far, accounting for 7% of direct payments in 2004 or KRW 129 billion (USD 104 million) [5]. Since 1991 the government has supported, under dual programmes through the Ministries of Agriculture and Environment, the construction of livestock waste treatment facilities up to nearly KRW 1.4 trillion (USD 1.24 billion) by 2003 [5].

Agriculture is also affected by national environmental and taxation policies. Agriculture is provided support for energy costs covering 48% of electricity delivery costs to farmers and the energy subsidy to agriculture, rural areas and fisheries amounting to an estimated KRW 150 billion (USD 113 million) annually [8]. Irrigation water charges, investment, operation and maintenance costs are subsidised [1, 9], and farmers are not charged for the cost of delivery when receiving water from large government dams [5]. But farmers provide labour for weed elimination, dredging, etc., to maintain irrigation facilities and this is estimated to be 35% of total irrigation operation and maintenance costs. The Government is seeking to address biodiversity concerns related to agriculture, in particular, by halting a number of projects that would have reclaimed wetland and tidal habitats for farm use, and by introducing wetland preservation schemes in co-operation with the Global Environmental Facility. The reclamation of the Saemangeum tidal flats for rice fields is the most notable example of these projects; launched in 1991, by 2004 it has cost KRW 1.7 trillion (USD 1.9 billion) [5]. An ecosystem conservation charge was introduced in 2001 which applies to newly converted paddy fields and other projects. It is set at KRW 250 000 (USD 200) per hectare, with a maximum tax intake

per project of nearly KRW 1.0 billion (USD 900 000) from 2006. The tax can be refunded if there is establishment of new green areas or reafforestation [5].

3.16.2. Environmental performance of agriculture

Pressure on water and land resources are the major environmental challenges for agriculture. These challenges are closely linked to high population density and economic growth, with a farming structure characterised by numerous small farms, dominated by rice production. This gives rise to environmental concerns with regard to agriculture's impact on water use, water retention, water pollution, soil quality, biodiversity and air emissions.

Agriculture accounts for nearly 50% of total water use and 20% of land use (2004). With over 60% of the country forested and mountainous, continued population growth, and a population density the highest in the OECD, there is intense pressure to convert farmland to other uses, but in some cases also convert land to agricultural use. Soils are "naturally" low in fertility as they originate from granite and granite-gneiss, with heavy summer rains leading, in the absence of conservation practices, to high levels of erosion on steep land, especially in mountainous cultivated areas [10]. The Asian monsoonal climate is suited to rice production but encourages pests, diseases and weeds resulting in intensive use of pesticides, and also rapid decomposition of soil organic matter.

The area of agricultural land at moderate to severe risk of erosion (greater than 10 tonnes/hectare/year) declined by 3% between 1990-94 and 2000-02. The share of agricultural land affected by moderate to severe rates of erosion rose slightly from 21% to 22% over this period, but mainly because of the much larger decrease in agricultural land area over the period [11, 12]. But with over three-quarters of farmland little affected by erosion, soil degradation from erosion does not pose an immediate threat to agricultural production. Even so, erosion is impairing the long term productivity on some steeper marginal land [13]. Moreover, while soil fertility, as measured by soil organic carbon content, deteriorated between 1990 to 1999, but by 2003 it had increased because of the greater use of compost and soil supplements with adequate application of fertilisers (Figure 3.16.3) [14].

Trends in water quality indicate that agriculture is an important source of pollutants. Agricultural water pollution has been identified as one of the most serious environmental issue that farmers need to address [5, 15]. While the estimated biological oxygen demand (BOD) discharges from agriculture have more than halved between the mid-1990s and 2004, other BOD sources decreased even more rapidly, such that agriculture's share in total BOD loadings (tonnes/day) rose from 9% to 24% over this period [5]. The principal pollutants are nitrates and phosphates, especially from livestock operations and, to a lesser extent, fertilisers, with concentrations increasing in some rivers, lakes and reservoirs [16]. However, there is more recent evidence that nitrate pollution of groundwater has decreased [17]. "Red tides" of decomposing algae, resulting from nutrient pollution (eutrophication) from agricultural and other sources, is also occurring in some coastal waters [18, 19], imposing high economic costs on fisheries and aquaculture [20].

The elevated levels of water pollution from agricultural sources are associated with rising levels of nutrient surpluses, being amongst the highest across OECD countries (Figure 3.16.2). Surpluses of both nitrogen and phosphate from agriculture have grown rapidly, mainly due to rising pig and poultry numbers [15, 21], although this is partly offset by a reduction in inorganic fertiliser use over the period 1990-92 to 2002-04 [15]. There is an accumulation of

phosphorus, heavy metals and other toxic elements in agricultural soils [13]. The build-up of phosphorus in agricultural soils from the overuse of fertilisers and livestock manure is more than twice that required for the optimal level of growth in some vegetable producing areas [22], however, overall agricultural use of phosphorus fertilisers declined by 33% between 1990-92 and 2002-04. Aside from natural processes, the chemical degradation of soils stems from inappropriate soil conservation practices and excessive use of fertilisers and manure [13]. Over 90% of livestock waste from larger livestock operations is returned to the land, with about 8% treated [5]. While the area of farmland and the number of farms adopting nutrient management plans have grown rapidly over the 1990s only about 20% of farms had adopted plans by 2000-03, and nutrient use efficiency (output/input) is among the lowest across OECD countries.

The 8% decline in pesticide use (1990 to 2003) has eased its potential pressure as a water pollutant (Figure 3.16.2). However, the intensity of pesticide use per hectare of land, among the highest across OECD countries, is still a concern reflecting the need to lower the loading of pesticides in water bodies [5, 23]. The use of pest management practices is extremely limited, with under 0.1% of the total arable and permanent crop area under integrated pest management in 2000-03 and under 1% of farms under organic management [11].

With growing competition for water resources nationally, agriculture is under pressure to manage water more efficiently [24]. Total water demand is expected to increase by 10% between 2001 and 2020, although the demand from agriculture is variously projected to expand by less than 2% [15, 25] or change little up to 2020 [24]. Agricultural water use increased by 7% over the period 1990 to 2002, compared to a 33% increase in total national water use (Figure 3.16.2). With farming accounting for 48% of water use, a 10% improvement in agricultural water use efficiency would be sufficient to provide 21% of current national water needs [15]. Upgrading existing irrigation facilities and infrastructure (*e.g.* about 30% of pumping stations are over 20 years old) has been identified as a key issue in improving water use efficiency by agriculture [9], especially in the context of resolving problems between competing users and of growing water scarcity [24]. Agriculture accounted for 40% of groundwater use (2002), but whether this water resource is being used beyond recharge rates is unknown.

Agriculture's water retaining capacity has declined in volume terms by around 15% over the period 1990 to 2004 (Figure 3.16.4) [26]. Korea considers that water retaining capacity (WRC) is a key environmental benefit associated with its agriculture, especially in view of the increasing incidence, severity and cost of national flood damage [25, 27]. Paddy rice fields account for 70% of agricultural WRC and are considered to provide other benefits, such as reducing soil erosion and enhancing biodiversity [22]. The key reason for the decline in WRC has been the 13% reduction in area farmed from 1990-92 to 2002-04, partly offset by an increase in the volume of on-farm water retaining facilities (*e.g.* small dams, reservoirs) by more than 50% over the 1990s [11].

Korea experienced the highest increase in ammonia emissions among OECD countries, but has phased out the use of methyl bromide. The main reason for the 27% increase in ammonia emissions, over the period 1990 to 1998 (Figure 3.16.2), was due to the expansion in total livestock production resulting in elevated levels of emissions [28], partly offset by the decline in fertiliser use for rice production (25% of agricultural ammonia emissions are derived from fertiliser use) [29]. The rapid increase in the number of farms adopting nutrient management plans over the 1990s may have slowed the rate of ammonia

emissions, but only about 20% of farms had adopted such plans by 2000-03. The use of ***methyl bromide*** (an ozone depleting substance) was phased out in the early 1990s, well in advance of the *Montreal Protocol* 2005 deadline.

There was a small reduction in agricultural greenhouse gas (GHGs) emissions over the period 1990 to 1999-2001. While total GHG emissions rose over this period by around 5%, they declined for agriculture by 6%, with farming contributing 3% to total emissions in 2001 (Figure 3.16.2) [30]. Much of the reduction in agricultural GHGs was due to the reduction in rice production, leading to lower methane emissions and nitrous oxide from the decline in fertiliser use, partly offset by an increase in livestock numbers [30]. The role of agriculture in ***carbon sequestration*** diminished over the period 1990 to 2003 (Figure 3.16.3), especially because of the conversion of farmland for urban and transport uses, but improvements in soil management practices and the conversion of some farmland for forestry has helped to increase carbon sinks.

Agricultural land reclamation and water pollution are damaging wild species not dependent on agriculture. The reclamation of tidal flats and wetlands for agricultural and industrial uses is an important threat to biodiversity, particularly for some migratory birds [5, 31]. Agricultural reclamation of these habitats over the past 10 years declined from a peak of 4 000 hectares annually to 2 000 hectares in 2000-01 [12]. This is significant for biodiversity as more than 50 internationally important bird species have been identified as migrating through these habitats [32]. A notable example is the Saemangeum tidal flat, which was included under a project in 1991 to be converted to rice fields, although, the future of this project in 2005 was uncertain. This habitat is a breeding ground for many aquatic species (*e.g.* fish, crabs) and a crucial feeding site for 50 000 shorebirds, including a number of species of international importance [5]. Additional threats to the decline and extinction of certain wildlife species from farming include: pollution of aquatic ecosystems from pesticides and nutrients [31, 33, 34]; and deforestation for agricultural development, nearly 17 000 hectares in 2000-01, although 7 000 hectares of this area was converted from agricultural to use for forestry [11].

At the same time the reduction and change in use of agricultural land is having an adverse impact on some wild species dependent on agriculture. Paddy rice fields together with rivers, tidal flats and lakes, provide habitat for more than a million migrant water birds [5]. The change in use of farmland, notably from paddy rice fields to urban use and to use for the vinyl-mulched or greenhouse culture of upland or vegetable crops, is reducing the foraging habitat available to some waterbirds [32, 35]. For example, numbers of Hooded Cranes (*Grus monacha*), which use paddy fields as a primary wintering habitat, have declined sharply due to the conversion of paddy rice fields [31, 35]. Paddy rice fields also provide a more species rich environment for birds compared to forest and mountain habitats, probably because they offer a more varied habitat. Even so, the reverse is true for mammals, possibly linked to the lack of suitable breeding sites on paddy rice fields compared to forest and mountain habitats [32].

3.16.3. Overall agri-environmental performance

Agri-environmental challenges for Korea are dominated by the impacts of rice cultivation on water and land resources, and increasingly the livestock sector. Agriculture is the major water user, in particular because of the dominance of rice cultivation, but demand for water by urban and industrial consumers is growing rapidly. Intense competition for land – Korea is the most densely populated OECD country – is also raising concerns, with the

loss of agricultural land to other uses offsetting certain environmental benefits considered to be associated with agriculture, principally flood mitigation and biodiversity.

Since the mid-1990s an effort is being made to establish environmental monitoring, including for agriculture [5]. The current lack of regularly collected data is impeding the capacity to accurately track the state and trends of Korean agri-environmental performance, most importantly in the areas concerning water use efficiency, water and soil quality, air emissions and biodiversity. The costs and benefits of using agricultural land and water retention facilities compared to non-agricultural land and water retention facilities to help mitigate flood damage are also unknown.

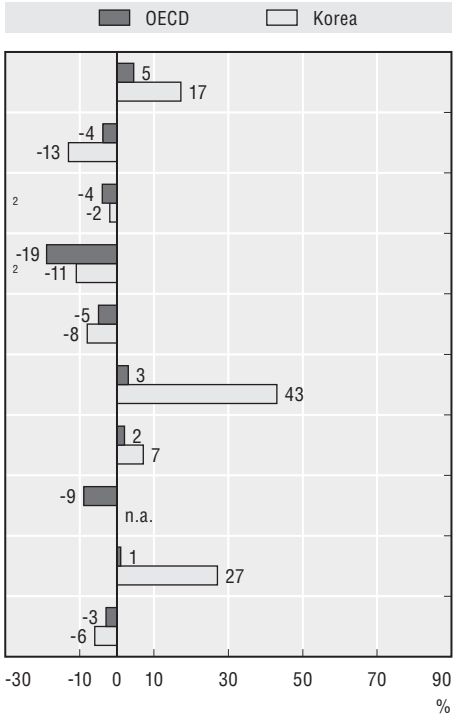
The net burden on the environment from agriculture is significant, but recent policy developments are beginning to address the issue. Policy initiatives are seeking to stimulate the adoption of sustainable farming practices, raise the efficiency of resource use, cut chemical input use, encourage the adoption of soil conservation practices, and address biodiversity concerns. There are also indications that farmers are becoming more receptive to adopting sustainable practices [4, 5, 7]. While fertiliser and pesticide inputs are subsidised, Government plans are to reduce their use by 30% from 1999 levels by 2005 [6]. In addition, the Ministries of Agriculture and Environment have jointly adopted a 10 year plan (2004 to 2013) to reduce pollution from livestock waste, after concluding that their separate programmes since 1991 have not been effective or efficient [5].

A new Direct Payment for Environmentally Friendly Livestock Practice was introduced in 2004 with a budget of KRW 5.8 billion (USD 5 million), for which cattle farmers are eligible if they recycle more than 60% of manure; and poultry and pig farmers if they reduce stocking densities by 20-30% below "normal" standards. Livestock producers can each receive KRW 13 million (USD 11 282) under the programme and an additional KRW 2 million (USD 1 736) if they apply stricter standards [3]. More broadly, the Prime Minister's office initiated a plan in 2005 for the comprehensive management of agricultural pollution in the country's four major river basins over the period 2006 to 2020 [5].

With the overall expansion of the agricultural sector, especially livestock, the pressure on the environment has increased over the past decade. This trend may continue over the next 10 years mainly because of the projected growth in livestock production, partly offset by the anticipated contraction in rice production. With the projected expansion in livestock output, except beef [36], this could lead to a further rise in nutrient surpluses with adverse impacts for water and air pollution. Nevertheless, the expected reduction in rice production could result in the continued decrease in fertiliser and pesticide use [36]. But continued use of high output-related policy support measures and subsidies for fertilisers, pesticides, energy and water, discourage farmers from reducing inputs or using them more efficiently, including, in the case of energy use helping to reduce greenhouse gas emissions [1, 5, 8, 9]. The need for greater efficiency in water use by agriculture is also important in view of problems arising from water scarcity and conflicts between competing users, especially as agriculture is the major water user, and the sector's use of water increased between 1990 and 2002. The continued loss of wetland and tidal habitats to agricultural development is having a damaging impact on internationally important wildlife habitats, in particular the Saemangeum tidal flats project for conversion to rice fields, although the future of this project in 2005 was uncertain [5].

Figure 3.16.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

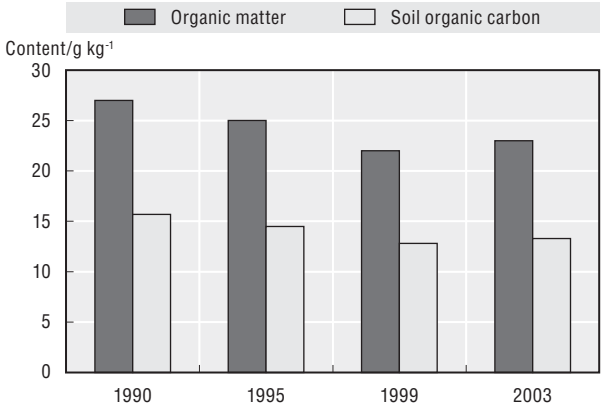
Variable	Unit		Korea	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	117	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–284	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	240	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	48	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–2 276	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+805	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+1 100	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	n.a.	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	+38	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–271	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

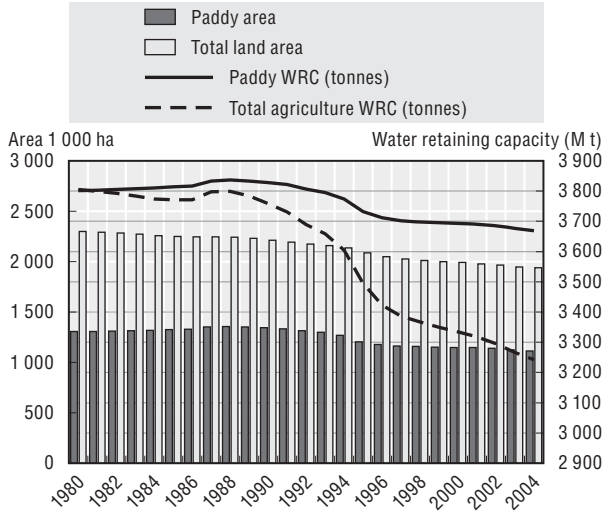
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.16.3. **Composition of soils**



Source: Rural Development Administration, Republic of Korea.

Figure 3.16.4. **National water retaining capacity of agriculture**



Source: Rural Development Administration, Republic of Korea.

StatLink http://dx.doi.org/10.1787/300615412861

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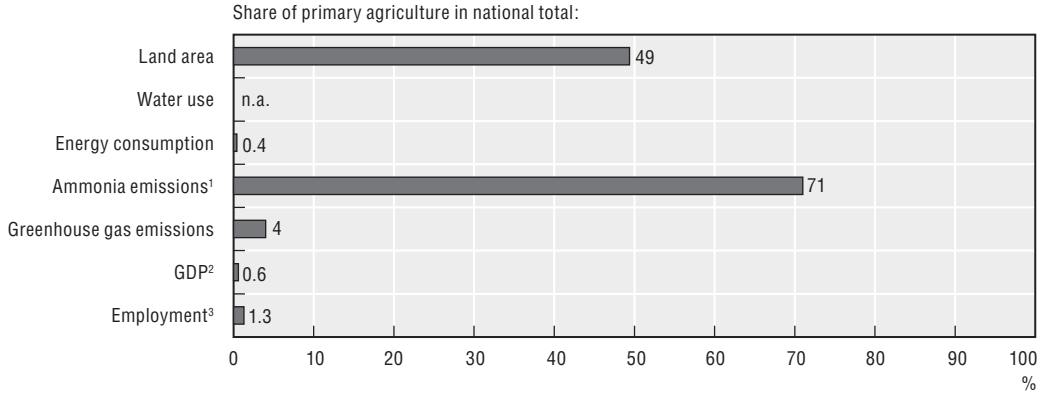
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3.17. LUXEMBOURG

Figure 3.17.1. **National agri-environmental and economic profile, 2002-04: Luxembourg**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2004.
3. Data refer to the year 2001.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.17.1. Agricultural sector trends and policy context

Agriculture's contribution to the economy has been small but stable in absolute terms since 1990, such that by 2003-05 the sector contributed 0.5% to GDP and 1.3% of employment, among the lowest shares across OECD countries [1] (Figure 3.17.1). While agricultural value added (annual growth at current prices) remained stable over the period 1990 to 2004 (allowing for temporary fluctuations), in real terms it increased over the period 1986 to 1998, but from 1998 to 2003 it was the only sector in the economy where growth declined by nearly 5% per annum [1, 2].

The area farmed increased by about 1.5% from 1990-92 to 2002-04, now accounting for over 50% of the total land area (Figure 3.17.2). Much of the increase in area cultivated was accounted for by the growth in area under pasture and maize silage, with the area under cereals declining [3, 4]. But some of the apparent expansion in area farmed is, in part, due to improvements in the land registration system linked to changes in agricultural policy. There was an increase in the production of bovine animals (for slaughterings and export of live animals) in the first half of the 1990s, and a slight decrease from 1996 onwards, especially in 2001 due to the BSE crisis. The production of pigs (for slaughtering and export as live animals) increased significantly in the 1990s and went through a cyclic variation from 1999 to 2004 reaching a minimum in 2002. Milk production was remarkably stable over the period 1990 to 2004, due to the EU-wide system of limitation of production. As the milk yield per cow has risen considerably during this period, the number of milk cows has declined [1].

Agriculture uses purchased variable inputs intensively, while the average farm size has increased since 1990. With the reduction in the number of farms (over 2 hectares) from about 3 300 in 1990 to 2 200 by 2005, the average farm size has risen sharply over this period from an average of about 38 hectares (1990) to over 70 hectares (2003-05) [3, 4]. Agriculture remains intensive by comparison with most OECD countries, with the use of some purchased variable inputs increasing since 1990, both pesticides and direct on-farm energy consumption (Figure 3.17.2), but the volume of inorganic fertiliser use declined (nitrogen and phosphorus) [4].

Farming is mainly supported under the Common Agricultural Policy, with additional national expenditure within the CAP framework. Support to EU15 agriculture has declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate) compared to the OECD average of 30% [5]. Nearly 70% of EU15 farm support is output and input linked, falling from over 98% in the mid-1980s. Annual agricultural budgetary expenditure (less CAP payments) was EUR 78 (USD 98) million in 2005, of which about 10% is for agri-environmental measures [1, 5].

Agri-environmental policies are mainly focused on reducing the intensity of farming and protecting biodiversity [1]. Nutrient policy under the EU *Nitrate Directive* started in 1997, with Luxembourg among the first of EU15 countries to develop an action plan to help those farmers to control nitrate pollution in *Nitrate Vulnerable Zones*. Under the *National Plan for Sustainable Development* (2001), the government established two key goals for agri-environmental policy up to 2010: first, to increase the area under organic management to 4 000 hectares or 5% of total agricultural land area; and second, to expand the area under agri-environmental schemes to 16 000 hectares or 20% of the total agricultural land area [6, 7]. The latter scheme includes measures for livestock extensification, establishing riparian buffer strips along stream and river courses, and biodiversity conservation, such as preserving hedges and hay meadows [1, 4].

Agriculture is impacted by national environmental and taxation policies. Under the *National Plan for Sustainable Development* (2001), the Plan recognises the need to protect soils (including in agriculture) against degradation, and restore the ecological functions of rivers [4, 8]. Farmers are provided an exemption on diesel fuel tax, but the budget revenue forgone from the concession is unknown [9]. To promote renewable energy production from agricultural biomass production, energy crops are provided support of EUR 45 (USD 56) per hectare, while investment grants are available to farmers for construction of biogas facilities of up to 60% of the total investment costs [1, 10, 11]. In addition, feed-in tariffs for electricity and heat produced from agricultural biomass are above average electricity tariff rates [10].

Some international environmental agreements have implications for agriculture. Agriculture is implicated by Luxembourg's commitment to reduce nutrients into the North Sea (*OSPAR Convention*), ammonia emissions (*Gothenburg Protocol*), and greenhouse gases (*Kyoto Protocol*), and also make commitments for biodiversity conversation under the *Convention on Biological Diversity* [4].

3.17.2. Environmental performance of agriculture

Overall the environmental pressure from agricultural activities have eased since 1990, but the intensity of farming remains high and pesticide and energy use have been rising. The key environmental challenges are to: continue to reduce water pollution from farm nutrients and pesticides; maintain soil quality; further reduce ammonia and greenhouse

gas emissions; and enhance biodiversity conservation efforts. As agriculture is largely rain-fed there is little use of irrigation.

In general soil erosion is not a concern across agricultural land, except for a few problem areas [8]. Current levels of soil erosion rates and other forms of soil degradation, however, are not very well known due to the lack of a national soil monitoring network, [8]. Overall soil erosion levels are low to moderate [8], while under agri-environmental measures the area under soil conservation practices (*e.g.* reduced tillage, erosion strips) has been increasing, reaching about 2% of agricultural land by 2003 [12].

The overall pressure from farming activities on water quality has been mixed since 1990. This is because agricultural nutrient surpluses have sharply declined, but pesticide use significantly increased since 1990. But determining the extent of agricultural water pollution is difficult due to the absence of pollutant monitoring stations in rivers, lakes and groundwater in predominantly agricultural areas. Some limited national data, however, indicates that over the period 1996-99 to 2000-03 eutrophication of surface water has deteriorated for nitrates but improved for phosphorus (Figure 3.17.3) [4, 7].

Agricultural nutrient surpluses decreased between 1990-92 and 2002-04, but surpluses per hectare of farmland remain amongst the highest in the OECD (Figure 3.17.2). Over this period surpluses (tonnes) of nitrogen fell by 43% and for phosphorus by 76%, mainly because of a: reduction in inorganic fertiliser use (nitrogen and phosphorus) and livestock numbers (*i.e.* lower manure output); and the higher uptake of nutrients, largely because of the increase in fodder maize and pasture production. Despite the reduction in the total volume of nutrient surpluses, the intensity (kg of nutrient per hectare of agricultural land) remains high compared to EU15 and OECD averages. This is mainly due to the elevated livestock density and the high ratio of grassland in comparison to arable land in Luxembourg. Organic fertilisers (on grassland) have a lower efficiency than mineral fertilisers used in regions with a higher ratio of arable crops. By 2002-04 nitrogen surpluses were over 50% above the EU15 average and for phosphorus 10% higher, probably reflecting the orientation of agriculture towards animal production, compared to less intensive nutrient surpluses often associated with arable farming systems. Moreover, the efficiency of nitrogen use (based on the balance volume ratio of inputs to outputs) is below the OECD and EU15 averages, and for phosphorus slightly above.

Given the growth in pesticide use since 1990 environmental risks are likely to have increased. Pesticide use (in volume terms of active ingredients) rose by nearly 70% between 1990 and 1999. The rising use of pesticides in the 1990s can be explained partially by the fact that up to 2002 the level of Value Added Tax (VAT) was particularly low in Luxembourg compared to neighbouring countries, and as a result some pesticides were not correctly reported in national statistics. With the increasing area under agri-environmental schemes (85% of the farms and 89% of the utilised agricultural area in 2005), however, this is helping to encourage farmers to use pesticides and fertilisers more efficiently. Additionally, the increasing area under ***organic management*** also limits the use of pesticides. Despite the rapid growth in the area under organic farming since the early 1990s, however, the share of organic farming in the total agricultural land area was about 2% by 2002-04, compared to the EU15 average of almost 4%, although by 2006 the share for Luxembourg had risen to nearly 3% [1, 6].

Agricultural ammonia emissions declined by 10% between 1990-92 and 2001-03 (Figure 3.17.2). The reduction in emissions was largely due to the decrease in nitrogen fertiliser use and lower livestock numbers, with the latter accounting for over 90% of

agricultural ammonia emissions. Agriculture accounts for more than 70% of ammonia emissions, which is low by the average of other OECD countries at over 90%. The contribution of agriculture in total emissions of acidifying substances has risen since 1990 as the reduction in other sources of acidifying emissions have fallen more rapidly [7]. Luxembourg has agreed to a ceiling in total ammonia emissions of 7 000 tonnes by 2010 under the *Gothenburg Protocol*. By 2001-03 emissions totalled 3% in excess of this ceiling, so Luxembourg will need to make a further cut in emissions to meet its commitments under the *Protocol*.

Agriculture greenhouse gas emissions (GHGs) declined by 6% between 1990-92 and 2002-04, close to the EU15 reduction of 7% over the same period, but lower than the economy-wide GHG emission reduction in Luxembourg of 9% (Figure 3.17.2). Luxembourg's commitment under the EU burden sharing agreement, part of the *Kyoto Protocol*, is to reduce total GHGs by 28% in 2008-12 compared to 1990 levels. Much of the decrease in agricultural GHGs was due to lower fertiliser and livestock numbers, with farming contributing 4% of total GHG emissions in 2002-04. There is no information on the trends in the ***soil organic carbon*** content of agricultural soils, but it is possible that with the growth in the area under permanent grassland since 1990 there has been an increase of carbon storage in agricultural soils. The conversion of permanent grassland to arable land is, however, currently excluded through cross-compliance measures and the landscape conservation scheme.

The rise in on-farm energy consumption increased (17%) was just over half the rate of the rest of the economy (31%) over the period 1990-92 to 2002-04 (Figure 3.17.2). While the rise in farm energy consumption contributed to higher GHG emissions, agriculture's share of total energy consumption is very low at less than 0.1% in 2002-04. The use of motor fuels and lubricants per hectare, the main items of on-farm energy consumption, remained stable over the last 10 years. There has been considerable growth in ***renewable energy production*** from agricultural biomass feedstock since the mid-1990s, mainly in the form of biogas [10]. But the contribution of agriculture to total primary energy supply was less than 1%, and this share is projected to change little up to 2010 [11]. Energy crops accounted for about 9% of the total agricultural land area by 2002-04, but there is no domestic biofuel production in Luxembourg [1].

With the overall pressure of agriculture on the environment easing this could have had a beneficial impact on biodiversity since 1990. Determining the impact of agricultural activities on biodiversity is, however, extremely difficult due to the paucity of data and research. In terms of ***agricultural plant genetic diversity***, crop varieties used in production increased in diversity between 1990 and 2002, most notably for cereals [13]. Moreover, there has been a gradual decline between 1985 and 2002 in the number of national crop varieties endangered or not at risk [13]. There is little or no information on the genetic diversity of livestock.

Changes in the use and management of agricultural habitats have been harmful to wild flora and fauna. The conversion of small farmland habitats, such as ditches, hedgerows, stone wall terraces has been a cause of the loss of certain flora and fauna. Also the drainage and fertilisation of nutrient poor wet grasslands has led to the disappearance of some wild plant species from these habitats [4, 14]. Since the introduction of measures concerning the protection of nature and natural resources in 1982 and the implementation of a landscape conservation scheme in 1996, however, the destruction of natural habitats, the reduction of permanent grassland and the drainage of agricultural land has been banned. For bird species whose primary habitat is farmland the trends appear to be mixed. Population numbers of the Northern Lapwing (*Vanellus vanellus*) and Little Owl (*Athene noctua*) have been in long term decline since the 1980s, while numbers of Grey herons (*Ardea cinerea*)

have risen over this period [7]. These trends are of concern as agriculture is estimated to have posed a threat, in the late 1990s, to around 55% of important bird habitats through changes in management practices and land use [15].

3.17.3. Overall agri-environmental performance

Overall the high intensity of farm input use exerts considerable pressure on the environment, although the trend of nutrient surpluses has been declining, but pesticide use has risen. Absolute levels of some agricultural pollutants remain high relative to average OECD standards and as a result the sector continues to be a potential source of pollution. Moreover, agricultural practices continue to pose a threat to biodiversity.

The lack of an adequate agri-environmental indicator monitoring system does not provide the necessary support for policy makers to assess agri-environmental measures [4]. While some areas of environmental monitoring related to agriculture have been developed, such as those related to ammonia and greenhouse gas emissions, for most other areas, notably concerning water pollution from agriculture and agri-biodiversity, monitoring is absent or very weak.

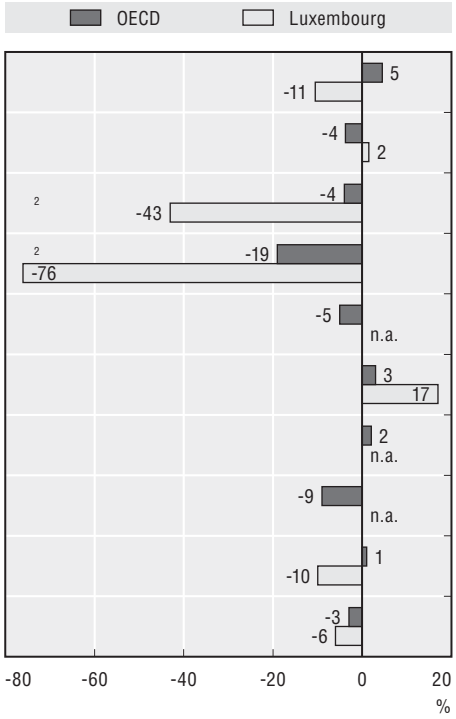
Agri-environmental measures have been considerably strengthened and expanded since 2000, compared to those measures first introduced in the early 1990s [1, 4]. In terms of meeting the government's 2010 agri-environment goals of increasing the area under organic management to 4 000 hectares and the area under agri-environmental schemes to 16 000 hectares, by 2005 (estimate) the areas achieved were respectively about 2 900 and 24 000 hectares, with an additional 3 250 hectares under agri-biodiversity schemes (Figure 3.17.4) [6]. Hence, in 2005 around 2% of the total agricultural land area was under organic management, 18% under agri-environmental schemes, and nearly 3% under biodiversity schemes.

Despite the strengthening of agri-environmental policies some problems persist. The EU Commission has been critical of the weakness of Luxembourg's efforts to adequately address its commitments under the EU *Nitrates Directive* [16]. Despite the reduction in the total tonnes of ***nutrient surpluses*** since 1990 the intensity (kg of nutrient per hectare of agricultural land) remains high in relation to the EU15 and OECD averages (Figure 3.17.2). In addition considerable improvements could be made to raise the efficiency of nutrient use, which is very low by OECD standards, especially for nitrogen. Moreover, risks of water pollution from ***pesticides*** run-off have increased with their growing use since 1990, although data on pesticide use and environmental risks are poor. While ***agricultural GHG emissions*** have decreased since 1990, further reductions might be achieved if the fuel tax exemption for farmers was removed, which acts as a disincentive to lower energy use, improve energy efficiency and further reduce GHG emissions. But the growing use of agricultural biomass to produce ***renewable energy*** (notably biogas) is helping to reduce GHG emissions.

Concerning biodiversity risks of future adverse impacts from farming remain, especially given the intensity of farming in Luxembourg. Meeting the 2010 agri-environmental goals under the *National Plan for Sustainable Development*, however, holds the potential to ease agricultural pressure on wild flora and fauna. Moreover, the recent introduction of agri-environmental measures should ease pressure on the environment, such as those addressing soil erosion and nutrient management.

Figure 3.17.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

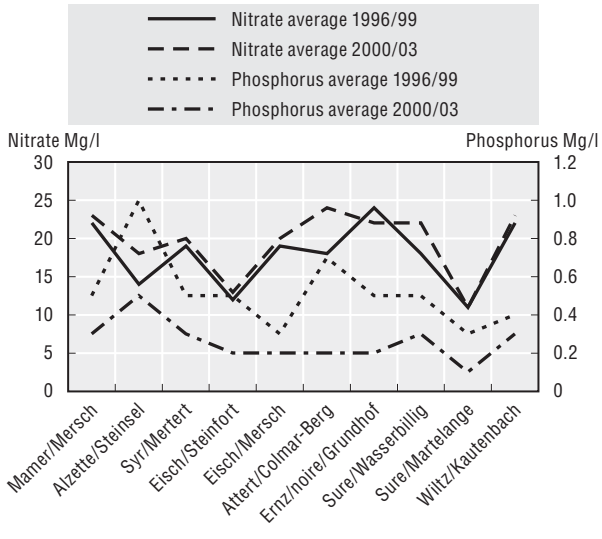
Variable	Unit		Luxembourg	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	89	105
Agricultural land area	000 hectares	1990-92 to 2002-04	2	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	129	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	11	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	n.a.	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+2	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	n.a.	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	n.a.	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–1	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–28	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

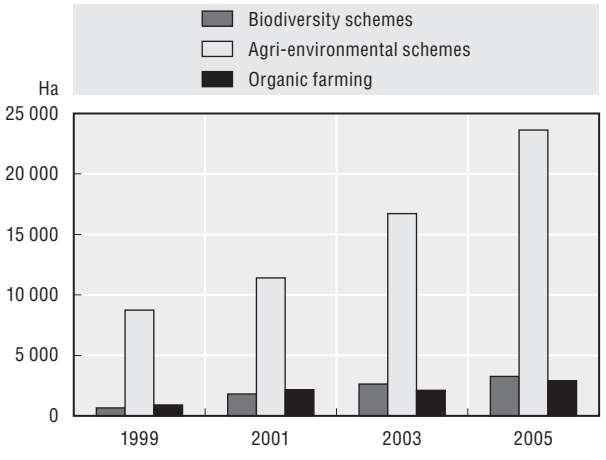
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.17.3. **Nitrate and phosphorus concentration in river sampling stations**



Source: Water Management Authority, Luxembourg.

Figure 3.17.4. **Agricultural land under agri-environmental schemes**



Source: Agricultural Technical Services Authority.

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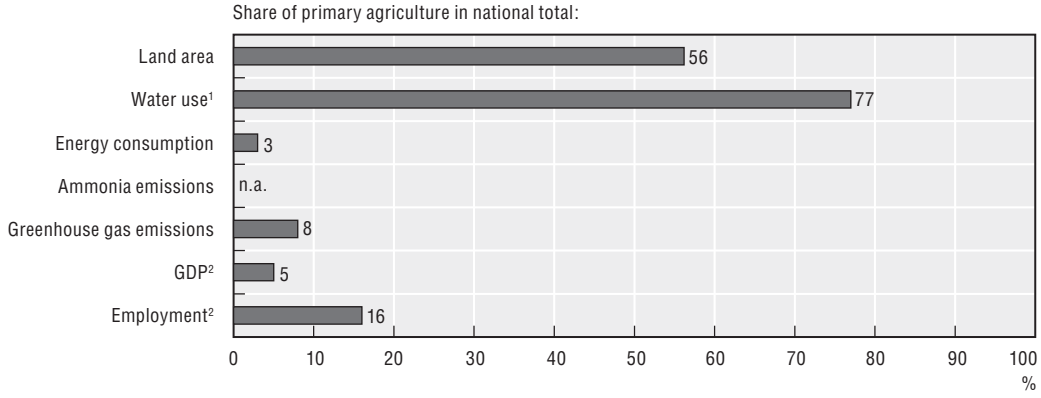
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3.18. MEXICO

Figure 3.18.1. **National agri-environmental and economic profile, 2002-04: Mexico**



StatLink http://dx.doi.org/10.1787/300643416640

1. Data refer to the period 2001-03.
2. Data refer to the year 2003.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.18.1. Agricultural sector trends and policy context

Agriculture plays an important but declining role in the Mexican economy. In 2003 primary agriculture accounted for about 5% of GDP and 16% of employment compared to 8% and 27% respectively in 1990 [1] (Figure 3.18.1). Nevertheless, 25% of Mexico's 103 million population live and work in rural, largely agricultural, areas. The rural population has increased by nearly 2 million over the past decade [2].

Mexico's agricultural sector is one of the most rapidly growing among OECD countries. The volume of agricultural production rose by 34% between 1990-92 and 2002-04, with crop production increasing by 26% and livestock 51% (Figures 3.18.2 and 3.18.3). The area farmed rose by 3%; while the volume of inputs also increased by 22% for pesticides, and 21% for direct on-farm energy consumption, although the use of phosphorus fertilisers remained stable, and nitrogen fertiliser use declined (–5%), as did the use of water (–10%) (Figures 3.18.2 and 3.18.4). Production is expanding by improving efficiency and increasing use of capital-intensive technologies. Nevertheless, farming is characterised by diverse structure and production systems. Large commercial arable farms, largely in the north, are capital intensive and rely on irrigation and purchased inputs. There are also range fed cattle and intensive pig and poultry operations in the north. Subsistence farms, mainly in the centre and south, grow staples such as maize and beans. The southern tropical zone has plantations and subsistence producers of coffee, sugarcane and bananas [2, 3].

Support to agriculture is below the OECD average and has declined over the last decade. Agricultural producer support fell from around 28% of farm receipts in the early 1990s down to 21% by 2002-04 (as measured by the OECD's Producer Support Estimate). This

compares to the OECD average of 31% over this period [4]. Nearly 80% of farm support is output and input linked, falling from 100% over the last decade. Agricultural policies consist mainly of market price support provided through border measures and payments to producers (PROCAMPO). The latter include payments for input use and technical assistance aimed at enhancing farm investment, especially in poor areas (*Alianza Contigo*). Border protection with Canada and the United States is being reduced within the framework of the North American Free Trade Agreement (NAFTA) [4].

Policies addressing agri-environmental concerns are limited. Agri-environmental payments are possible under PROCAMPO, for soil and water conservation, although farmer uptake of these payments has been limited to date [3]. A number of programmes support forestry but only one is aimed specifically at the reaforestation of farmland, and eco-certification of shade-grown coffee plantations is being developed [3]. Farmers are exempt from the 15% value added tax on pesticides [5].

Economy-wide environmental and taxation policies and international environmental agreements also affect agriculture. Under the *Law on Energy for Agriculture* diesel fuel and electricity subsidies reduce farmers' energy costs. The programme to subsidise diesel for farm production, implemented since 2003, provided payments of MXN 1.2 billion (USD 106 million) in 2004 [4]. The total agricultural electricity subsidy rose from MXN 3.8 to 5.4 billion (USD 390-480 million) from 2002 to 2004 [4, 6]. Under the *Federal Law on Water Taxes* (1982), a system of water abstraction charges was established, but farmers were exempt from these charges up to 2003, although they are liable for water pollution charges introduced in 1992 under the same law. Budget transfers to the government *National Water Commission* agency reduce farmers' irrigation costs: currently farmers are paying 80% of irrigation operating and maintenance costs compared to 20% in the early 1990s, and government expenditure on irrigation infrastructure and maintenance amounted to MXN 1 468 (USD 135) million in 2006 [4].

The International Boundary and Water Commission resolves water issues at the Mexican-United States border, including allocation of water resources for irrigation, while the *North American Commission for Environmental Co-operation*, established under NAFTA in 1994, addresses regional environmental issues, for example those concerning transgenic maize [7]. The *National Environment Programme* also provides a framework for biodiversity and natural resource conservation.

3.18.2. Environmental performance of agriculture

The main agri-environmental concerns relate to water resources and deforestation, with the latter being of importance for soil conservation and biodiversity. Also of increasing concern are issues related to agricultural pesticide use, especially methyl bromide, water pollution, and greenhouse gas emissions.

Agriculture's use of the country's natural resources is significant, accounting for 56% of land use (2002-04) and nearly 80% of water use (2001-03). Over the period 1990-92 to 2002-04 the growth in the agricultural land area was amongst the highest across OECD countries (Figure 3.18.3). In excess of 75% of the country lies in semi-arid or arid zones where more than half of agricultural production takes place. While overall population density is low by OECD standards, Mexico has the highest rate of population growth across the OECD, which coupled with high rates of industrial growth, urban expansion and a growing but poor rural population, there is considerable pressure on land, water and biological resources.

Soil erosion is one of Mexico's most serious ecological problems with agriculture identified as the major cause of soil degradation [3, 8]. Between 60-80% of the total land area is affected by erosion, with around 40% suffering high and severe erosion [3, 8]. Recent evidence reveals that agriculture is the major cause of soil degradation from erosion accounting for nearly 80% of affected areas. The soil degrading factors caused by agriculture are overgrazing, excess irrigation, tillage burning, excessive tilling [9] and inadequate adoption of soil conservation practices [8].

Water pollution from agriculture tends to be mainly confined to irrigated areas where farm chemicals are widely used [3]. But the expansion of intensive pig, poultry and dairy operations is leading to a greater incidence of water pollution from livestock effluents, even though overall cattle numbers have declined since 1990. [10]. The national nutrient surpluses of nitrogen and phosphate are very low by OECD standards, with most eutrophic pollution of water usually associated with urban and industrial sectors (Figure 3.18.1) [11]. There has been a slight decrease in nutrient surpluses, mainly because of declining cattle numbers; only a small increase in nitrogen fertiliser use; a drop in the use of phosphate fertilisers; and an increase in crop production (Figure 3.18.4). These changes have led to improvements in nutrient use efficiency (*i.e.* the ratio of nutrient outputs to nutrient inputs).

Pesticide use increased by 22% over the period 1993-95 to 2001-03 (Figures 3.18.2 and 3.18.4). Pesticide use is not widespread, partly because subsistence farmers cannot afford to use them, although total use has expanded over the 1990s. The use of two persistent organic pesticide pollutants, chlordane and DDT, has decreased over the past 20 years, and sales were prohibited as from 1998 and 2002 respectively [3]. Even so, the persistence of these pesticides, and possible continued illegal use [12], is polluting some coastal waters, with risks to human health from fish consumed from these waters [13], although there is little information on the overall impact of pesticides on ecosystems [5] and human health [14]. Recent research reveals, however, that reported incidents of pesticide poisonings have decreased by more than half between 1998 and 2002, although the incidence of poisonings is under-recorded [14].

Demand for water by agriculture is exceeding renewable supply and aquifers are being depleted [10]. Competition for water resources, especially in north-central regions, is intensifying because of the growth in population; economic activity; and water demand from irrigated agriculture. Irrigation accounts for nearly 80% of total water use and 50% of farm output, with 70% of farm exports dependent on irrigation (2001-03) [3]. About a third of agricultural water is from groundwater, with agriculture accounting for 70% of groundwater use (1997) [6]. The overexploitation of aquifers is a growing problem, with 32 overexploited aquifers reported in 1975 rising to 102 in 2005. Nearly 60% of groundwater for all uses is extracted from aquifers above recharge rates [6]. The unsustainable use of groundwater resources has raised concerns for the depletion of water to support aquatic ecosystems, especially wetlands, and a consequent increase in the salinity of soils [6]. Projections to 2010 suggest that water demand may rise sharply and further intensify competition for water between agriculture and other consumers [15].

Competition for water resources is especially acute on the Mexican-United States border, because of the over exploitation of water, notably by agriculture, from the border Rio Bravo river, called the Rio Grande in the US [16, 17]. Only around 45% to 50% of water extracted reaches irrigated fields [3, 6], because of insufficient investment in irrigation infrastructure and the relatively low share of irrigation water and energy costs in farmers total input

expenditure [18]. Even so, there has been some improvement in irrigation water application rates (megalitres per hectare of irrigated land) declining by 12% between 1990-92 and 2001-03. The electricity subsidy for agriculture has lowered pumping costs for irrigators, with horticultural producers the main beneficiaries [4].

Trends in agricultural air emissions have shown mixed results since 1990. Agricultural ***ammonia emissions*** may have increased between 1990 and 2004, but ammonia emission data are not regularly collected and Mexico is not a signatory to the *Gothenburg Protocol* to limit emissions. The likely increase in ammonia emissions are from the increase in livestock production since 1990 partly offset by the reduction in the use of nitrogen fertiliser. For ***methyl bromide*** (an ozone depleting pesticide, particularly used in the horticultural sector as a soil fumigant) Mexico along with most OECD countries has substantially reduced its use over the period 1995 to 2004. Under the *Montreal Protocol on Substances that Deplete the Ozone Layer*, Mexico, which is classified as a developing country under the *Protocol*, agreed to reduce methyl bromide use by 2002 to 1995-98 levels, which it has achieved, with a further 20% reduction in 2002-05 and elimination by 2015, except for limited purposes [3].

The over 40% increase in agricultural greenhouse gas (GHG) emissions between 1990 and 1996 was among the highest across OECD countries (Figure 3.18.2). The increase in agricultural GHGs is largely attributed to rising livestock numbers, and agriculture contributes around 8% of national total GHGs. Methane emissions account for nearly 80% of agricultural GHGs (in CO_2 equivalents), mainly from livestock and to a lesser extent rice production, while nitrous oxide accounts for much of the remainder through fertiliser use [3, 19]. Considerable stocks of ***terrestrial carbon*** are being lost with the conversion of forests to agricultural land, but little data exist on the level of these losses [21]. However, there are opportunities for Mexican agriculture to sequester carbon, as carbon accumulated in some agricultural ecosystems is higher than carbon in the soil of secondary degraded forests [20].

Direct on-farm energy consumption rose by 21% compared to an increase of 10% across the economy, over the period 1990-92 to 2002-04, has also contributed to the increase in GHGs (Figure 3.18.4). Agriculture accounted for 3% of total energy consumption in 2002-04. Much of the increase in energy consumption is explained by the expansion in use and size of machinery as a substitute for labour since 1990.

Agricultural expansion over the past decade has resulted in growing pressure on wild species and natural habitats. This is significant because Mexico is identified as one of the world's megadiverse countries, with around 10% of the world's flora and fauna species [3]. The rate of deforestation is amongst the highest in the world at over 1% per annum over the 1990s, with clearing for agricultural purposes identified as the major cause for the lost of temperate and tropical forests. This is closely linked to the growth in the rural population; rural poverty [3]; and an increase in beef production, leading to the conversion of forests into grazing land [22]. Agriculture is also exerting pressure on aquatic environments (rivers, lakes, wetlands and coastal zones), from increasing levels of livestock effluents and diffuse pollution through the use of chemicals in arable farming [3].

There are environmental and economic risks associated with the loss of agricultural genetic resources, especially for crops. Mexico is recognised as a "Vavilov" centre, which is an area where crops, such as maize, were first domesticated and have evolved over several thousand years [23, 24]. Genetic erosion of maize varieties, shows a loss of 80% of local varieties compared to the 1930s [23], and more recently possible contamination of

domesticated landraces and wild relatives from transgenic maize [24, 25]. The environmental and socio-economic costs and benefits associated with the use of transgenic maize (many subsistence farmers grow maize as a staple crop), and the loss of genetic resources, are complex and not fully understood, but are the subject of much ongoing research in Mexico and internationally, such as by the *North American Commission for Environmental Co-operation* [7].

3.18.3. Overall agri-environmental performance

Deforestation and conservation of water resources are the two key agri-environmental challenges in Mexico. Agriculture has been identified as a major cause of deforestation, which has adverse environmental implications for biodiversity, soil erosion and loss of carbon stocks. With growing competition for water in the drier regions of the country, agriculture, as the major user of water resources, is under increasing pressure to improve its efficiency of water use.

Mexico will require time and resources to establish adequate monitoring systems to deal with the environmental challenges it needs to address [3]. A start has been made with environmental monitoring, including efforts related to agriculture, such as the 2001 national soil inventory [8]; and the 1998 national survey of biodiversity by the National Commission for Biodiversity. However, these efforts require strengthening if they are to provide useful data for policy makers.

Limiting the adverse impacts of agriculture on the environment poses a formidable challenge. Recent developments suggest, however, some progress is being made toward reducing agriculture's adverse environmental impacts and increasing environmental services. A number of persistent organic pesticide pollutants have been prohibited, and the soil and water conservation infrastructure is being rehabilitated. A new programme on Water Rights has provided MXN 460 (USD 43) million in 2003, and MXN 227 (USD 20) million in 2004, to purchase water rights in areas where aquifers are overexploited, with an estimated 170 million cubic metres of water bought from producers in 2004 [4]. Mexico has a high percentage of "shade grown" coffee compared to other countries, which offers a higher quality habitat for biodiversity, and introduced an eco-certification system to provide incentives to "shade grown" and organic coffee production [3, 26, 27].

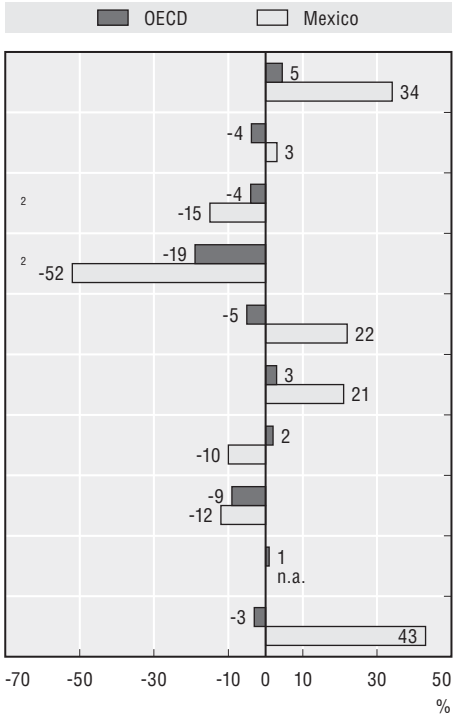
The North American Commission for Environmental Co-operation has recommended that Mexico should minimise the impact of growing transgenic maize and also mill transgenic grains immediately they are imported [7]. The government also amended its law on genetically modified crops in 2005 by limiting the release of genetically modified maize in centres of origin such as Oaxaca, Veracruz and Yucatan, in order to safeguard the diversity of domestic maize.

Pressure on the environment from agriculture has increased considerably since 1990. This trend is expected to continue over the next decade as projections indicate further expansion of the agricultural sector [28]. The adverse impacts of agriculture on the environment are attributed to the expansion in the area cultivated and grazed at the expense of forested land; poor soil conservation practices and deforestation resulting in major areas of land subject to elevated levels of erosion; and, also the high rates of water loss in irrigated areas through inefficient irrigation practices. Agricultural water and electricity charges are low by comparison with those paid by industrial and urban consumers, but reforms from 2003 have reduced the level of support [3, 11].

Water policy reforms have helped toward improving water use efficiency and reducing losses and there has been some improvement in irrigation water application rates per hectare irrigated [3, 29]. But subsidies for water charges and electricity for pumping are undermining the efforts to achieve sustainable agricultural water use and, in the case of energy, reduce greenhouse gas emissions. There is also concern that the subsidy to electricity is also exacerbating the pumping of groundwater and the growing overexploitation of this resource above recharge rates [6]. Moreover, the irrigation and electricity subsidy appears to be in contradiction to the new programme to purchase water rights from farmers, raising the costs to the government of achieving their environmental objectives [4].

Figure 3.18.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

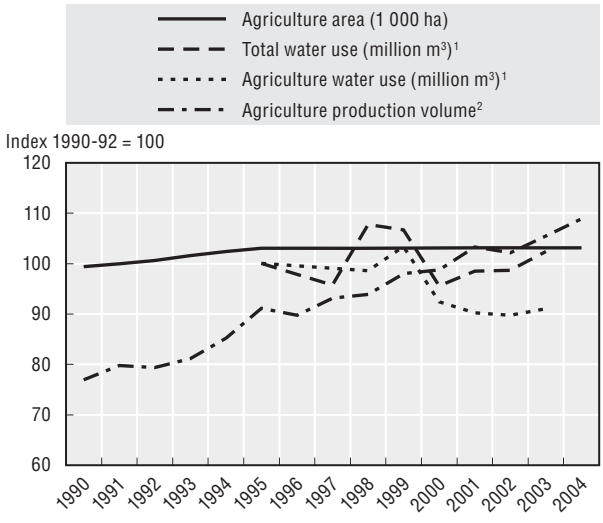
Variable	Unit		Mexico	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	134	105
Agricultural land area	000 hectares	1990-92 to 2002-04	3 267	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	22	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	1	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	+7 070	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+476	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–6 049	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	8.7	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	n.a.	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	+16 811	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

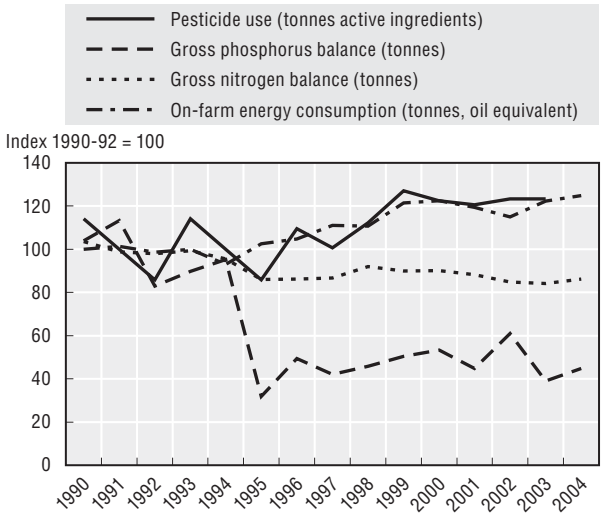
Figure 3.18.3. **Trends in key agri-environmental indicators**



1. Index 1995 = 100.
2. Index 1999-2001 = 100.

Source: OECD Secretariat.

Figure 3.18.4. **Trends in key agri-environmental indicators**



Source: OECD Secretariat.

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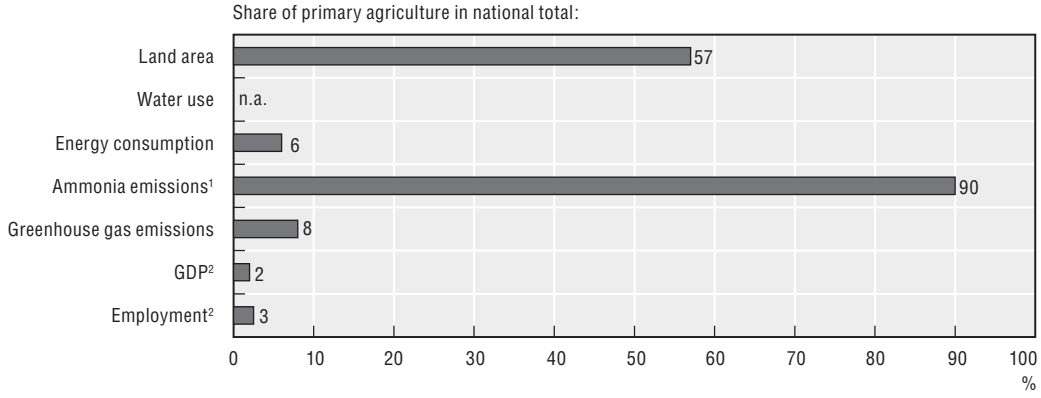
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3.19. NETHERLANDS

Figure 3.19.1. **National agri-environmental and economic profile, 2002-04: Netherlands**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2003.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.19.1. Agricultural sector trends and policy context

Overall the agricultural sector has been contracting, with a reduction in the volume of production of nearly –10% and in the area farmed by –3% over the period 1990-92 to 2002-04. As a consequence the share of primary agriculture was around 2% of GDP and 2.5% of employment in 2003 [1] (Figure 3.19.1). However, within this overall decrease there has been an expansion in the horticultural sector, which now contributes around 40% of agricultural gross value added [1].

Agriculture makes intensive use of inputs resulting in high crop and livestock yields in comparison to most other OECD countries [1]. Livestock densities per hectare are among the highest in the OECD [2]. Purchased farm input use has in general declined more rapidly than agricultural production, suggesting that production intensity is diminishing and economic efficiency increasing over the period 1990-92 to 2002-04 (Figure 3.19.2). For example, the volume of inorganic fertiliser use fell by –36% for phosphorus, and –27% for nitrogen, and pesticides fell by over –50%. In contrast, direct on-farm energy consumption rose by 5%, largely reflecting the growth in the horticultural sector.

Farming is mainly supported under the Common Agricultural Policy, together with additional national expenditure within the CAP framework. Support to EU agriculture has declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate). This compares to the OECD average of 30% [3]. Nearly 70% of EU farm support is output and input linked, falling from over 98% in the mid-1980s. The total national agricultural budget (including CAP support) was EUR 1.9 (USD 2.4) billion in 2004, with environmental expenditure around EUR 500 (USD 625) million annually, or

about 5-6% of agricultural gross value added [1, 3]. It is estimated by the Ministry of Agriculture that in 2003 the agricultural sector incurred costs totalling EUR 850 (USD 960) million in order to meet environmental regulations. EUR 650 (USD 730) million of this sum was spent to meet nutrient measures; EUR 90 (USD 100) million for acidification and air quality control; EUR 50 (USD 55) million to reduce pesticide use; and EUR 20 (USD 22) million to meet waste measures.

Agri-environmental policies mainly focus on reducing pollution. There have been three phases in nutrient policy: first, 1984-90, stopping the increase in livestock production; second, 1990-98, a step wise decrease of pressures resulting from surplus quantities of animal manure by using application limits and a manure quota system; and third, 1998-05, balancing farm level nutrient inputs and outputs through a compulsory *Minerals Accounting System* (MINAS), farmers being subject to levies when nitrogen and phosphorus surpluses exceed certain limits [2, 3, 4, 5, 6]. The annual cost of the nutrient policy rose from near zero in 1984 to EUR 400 (USD 380) million by 2002 [4]. There were also nutrient reduction costs through livestock farm closure schemes during 1998-2003, of EUR 710 (USD 700) million [2]. The *Nature for People, People for Nature* and *Subsidy Scheme for Nature Management* programmes include farmer environmental management agreements covering meadow birds, floral species and cultural landscapes.

Agriculture is affected by national environmental and taxation policies. Farming is assisted through environmentally important tax reductions. The following figures give estimates of annual budget revenue forgone in early 2000 [7] through these tax reductions: energy used for heating greenhouses [EUR 113 (USD 124) million]; on-farm diesel use [EUR 18 (USD 20) million]; and exemption from the groundwater abstraction tax up to a certain limit [EUR 17 (USD 19) million] [5, 8]. Agriculture also contributed 3% of total environmental tax revenues in 2002, mainly from nutrient levies [9]. Support and higher feed-in tariffs are provided for farm biomass used as a bioenergy feedstock [10]. Successive four-year *National Environmental Policy Plans* (NEPP) include environmental targets which affect farmers for pesticides, acid deposition, and eutrophication [5, 11].

To comply with international environmental agreements, agriculture has been set targets, for reducing nitrogen and phosphorus emissions into the North Sea (*OSPAR Convention*) and ammonia emissions into the atmosphere (*Gothenburg Protocol*). Agriculture is also implicated by national commitments under the *Kyoto Protocol* to reduce greenhouse gases and biodiversity conservation under the *Convention of Biological Diversity*.

3.19.2. Environmental performance of agriculture

With among the highest population density in the OECD area, pressure on land resources is high. Farming accounts for almost 60% of land use (2002-04), with most of the reduction in the area farmed since 1990 converted to urban use and, to a lesser extent, nature areas. About 25% of the country lies below sea level, protected from the sea by barriers of dunes and dykes [5, 12]. The main environmental challenge is the control of nutrient use, but also important is the reduction of groundwater use, drainage, and greenhouse gas emissions, as well as the improvement of energy efficiency, and the protection of biodiversity.

Soil quality is generally high [13]. Less than 1% of farmland suffers from high water erosion (above 14 tonnes/hectare/year), and wind erosion affects only about 2% of farmland [14, 15]. There is some evidence that intensive potato production in the northeast has contributed to wind erosion and soil organic carbon losses as a consequence of bulbs/pasture production systems [13] and ploughing grasslands [14, 16].

Water pollution originating from agriculture is an important environmental concern. While recent trends indicate that the pressure from farming on water quality is diminishing, absolute levels of pollution remain amongst the highest across the OECD. Agriculture is the major source of nutrients, pesticides and the only known source of heavy metals in water. Pollution from endocrine disrupters and veterinary medicines in terms of potential impacts on human and wildlife reproductive systems is also a concern. The total external costs of agricultural water pollution are unknown, but in the late 1990s the annual external costs of eutrophication associated with nitrate emissions was estimated at EUR 600 (USD 540) million [17], and for treating drinking water polluted with nitrates at EUR 23 (USD 21) million [18].

Nutrient surpluses per hectare of agricultural land, among the highest in OECD countries, were greatly reduced between 1990-92 and 2002-04: by about 34% for nitrogen and nearly 50% for phosphorus, with much of the decrease occurring after 1995 (Figure 3.19.2) [4, 17, 19]. The decline in surpluses is attributed to lower fertiliser use and smaller livestock numbers [20]. Despite the decline in fertiliser use, the intensity of use remains high in relation to the OECD average (Figure 3.19.2) [1, 5]. More farmers are improving their nutrient management practices, with the share of farmland under nutrient plans rising from 40% in 1995-99 to over 80% by 2000-03, largely because nutrient management under MINAS became compulsory as from 2001. Storage capacity for manure also grew over the 1990s, with over 80% of dairy and pig farms having storage capacity for at least 5 months of manure production [21]. Infringements of nutrient regulations were found in over a quarter of farms inspected in 2002 [21].

Agriculture is the major source of nutrients in water [21]. Farming contributes more than 50% of the nitrogen and phosphorus loading to surface waters. The share of agriculture is increasing in relation to other sources of nutrient pollution, mainly sewage and the industrial sector, which have declined more rapidly. Farming is also the main source of groundwater and marine water nutrient pollution. Some two thirds of nutrients entering Dutch rivers are from other countries [17, 21]. The share of monitoring sites in farming areas where pollution levels exceed drinking water standards for ***surface water***, are 70% for nitrates and 60% for phosphorus. Agricultural nitrate pollution of surface water has declined since the late 1990s, but phosphorus pollution has been decreasing since the early 1990s, although annual mean concentrations of nitrogen and phosphorus in surface water by 2003-05 remained above *Maximum Tolerable Risk Levels* (Figure 3.19.3) [2, 21, 22].

Around 12% of shallow groundwater monitoring sites in farming areas have pollution levels that exceed nitrate drinking water standards, but the share has been declining since the mid-1990s and varies with soil type [2, 4, 21]. For deep groundwater (> 30 m depth) nitrate pollution is still rising because of the long time lags associated with nitrate leaching [21]. ***Coastal nutrient pollution*** has also declined over the past 10 years, but a 2002 OSPAR Convention assessment concluded that the entire Dutch coastal zone was eutrophic [21]. Levels of cadmium (derived from fertilisers) in fish and shellfish has also risen [5].

The over 50% reduction in the volume of pesticide use (active ingredients) was amongst the highest in the OECD during 1990-92 to 2002-04 (Figure 3.19.2). However, the trend in use stabilised over the period 2000 to 2004 [23], but the intensity of use per hectare remains high [1, 5]. Pesticide use has been decoupled from crop production, although the reduction in pesticide use was offset, to some extent, by higher use in the horticultural sector [5, 24]. The cut in pesticide use met the NEPP1 target which sought a reduction of 50% by 2000

from 1984-88 levels [5]. Pesticide risk indicators for the period 1998-2001 show a lowering of toxic effects on ecosystems and leaching into groundwater. In some regions pesticide concentrations exceeded drinking water standards [5]. The 4% of the agricultural area located in drinking water abstraction areas seems to be more vulnerable to pesticide leaching than the rest of the area farmed [25]. Therefore, special measures have been introduced for pesticide registration to prevent groundwater pollution in drinking water abstraction areas.

There are also pressures on water quality from agricultural heavy metals and pathogens. Loadings of heavy metals (copper and cadmium) on farm soils, mainly derived from manure and fertilisers, fell between 1990 and 1995 but then stabilised up to 2001 [26, 27]. Loadings of zinc rose, linked to corrosion from galvanised steel in greenhouses, although since 2001 agreements have been made with the horticultural industry to reduce this form of pollution [28]. In some regions heavy metal pollution exceeds drinking water standards [5], and there are concerns that their accumulation in soils may lead to leaching over hundreds of years [27]. An estimated 10% of drinking water supplies exceeded the standards for faecal bacteria and some wells where *E. coli* was detected were closed in 2001 [14].

Agriculture accounts for only about 1% of total water use, with 80% of the water used for irrigation. Around 30% of farmland is irrigated [29], and the area of land under irrigation rose by 1% between 1990-92 to 2001-03. About 50% of water used by agriculture is from groundwater, 25% from surface water, and much of the rest piped tap water [29]. Agriculture has contributed to the overexploitation of groundwater [5], which is important as farmers account for about 10% of total groundwater use [29]. Groundwater depletion coupled with agricultural drainage has harmed natural ecosystems on around 15% of the total land area, and possibly up to 5% of land is affected by saltwater intrusion [5, 17]. Since 2002, as part of the plan to address the pressure on groundwater resources, a national and provincial tax has aimed at providing incentives to use surface water [5]. Farmers are exempt from the national groundwater tax if their use is under 40 000m3/year, which has encouraged them to use multiple smaller pumps to avoid the tax [30]. Moreover, around 90% of the irrigated area is under low efficiency high-pressure rain gun application technology.

Ammonia emissions from agriculture have declined continuously by 48% between 1990 and 2003, the largest reduction across the OECD (Figure 3.19.2) [5]. Farming accounts for over 90% of total ammonia emissions, mainly from livestock, and contributes about 30% to problems of acidification [31]. About two thirds of ammonia emissions are of domestic origin, while the Netherlands contributes to deposition in Germany and the North Sea [5]. Much of the reduction in emissions is due to: obligatory regulations to cover livestock manure facilities and use low emission spreading practices; lower livestock numbers (manure accounts for over 90% of emissions); and to some extent use of low emission livestock housing. A 2001 survey showed that only 15% of pigs were housed under low emission conditions [5, 32]. Ammonia emissions are expected to meet the EU and *Gothenburg Protocol* emission targets by 2010, but not the stricter NEPP4 target [11, 31]. Nitrogen deposition levels across the country are too high for the recovery of natural habitats, such as heathland and peat bogs, although there are regional differences [11]. Currently about 10% of natural habitats are protected from acidification, compared to the NEPP4 target of protecting 20-30% by 2010 [5].

Agricultural greenhouse gas (GHG) emissions declined by 18% between 1990-92 and 2002-04, and accounted for 8% of total national emissions in 2002-04 (Figure 3.19.2).

This compares to no change in total national GHG emissions over the same period and a *Kyoto Protocol* reduction target of –6% by 2008-12 under the EU *Burden Sharing Agreement*. The fall in GHGs was largely due to lower emissions of methane and, to a lesser extent, nitrous oxide, due to reduced livestock numbers and nitrogen fertiliser use, and improved manure management [33]. There was also a decrease in carbon dioxide (CO_2) emissions from agriculture. The potential loss of soil organic carbon in farmed soils and possible underestimation of GHG emissions from grassland ploughing [16], might be offset, to some extent, by the conversion of farmland to forestry over the 1990s and the growth in agricultural biomass for bioenergy production. The share of bioenergy in national heat, power and transport fuel production is under 1% [10].

Direct on-farm energy consumption rose by 5% over the period 1990 to 2004 (Figure 3.19.2). Most of this occurred in the first half of the 1990s, since when consumption has decreased [34]. Nearly 85% of on-farm direct energy consumption in 2001 was used for heating greenhouses[34], with farming accounting for 6% of total national energy consumption in 2002-04. A target has been set to reduce energy use per unit of production by 65% by 2010 compared to 1980 levels [31]. But while agriculture achieved a nearly 2% per annum improvement in energy efficiency over the 1990s [10], it has been estimated this rate needs to rise to 4.5% per annum between 2000 and 2010 to realise the government energy efficiency target [35]. The agricultural energy use per unit of production, however, almost halved between 1980 and 2003 [36].

The high intensity of agriculture has exerted substantial pressure on biodiversity. The main causes of this pressure derive from: acidification of natural habitats; drainage of farmland (lowering groundwater tables); pollution of aquatic ecosystems from eutrophication, pesticides and pathogens; and land use changes, including loss of semi-natural biotopes, ploughing of grasslands and conversion of farmland to urban use [5, 37]. Trends in ***agricultural genetic resources*** show that for *crops* extensive *ex situ* collections exist and are being increased, while *in situ* conservation is limited to fruit trees and some grasslands, as most traditional varieties were replaced many decades ago [14, 38]. For livestock all endangered breeds are included under conservation programmes with growing interest for *in situ* conservation of rare breeds and an expansion of genetic material in gene banks [39].

Over 50% of terrestrial flora and fauna species depend on farmland as habitat. Farmland bird populations declined by over 1% annually during 1990 to 2003, but the rate of decline accelerated over 2000 to 2004 to more than 4% annually, although the reasons for this are not yet known (Figure 3.19.4) [40]. Some bird species are in a critical situation, such as the Black Tailed Godwit (*Limosa limosa*) and the Skylark (*Alauda arvensis*) (Figure 3.19.4) [40, 41, 42]. The Netherlands has an international responsibility for some of these species, including, for example, the Black Tailed Godwit, with about 50% of the European population found in the country [43]. Numbers of reptiles (*e.g.* adders and lizards) on heath land have also declined by about a third between 1994 to 2003, mainly because of agricultural habitat fragmentation, and groundwater withdrawal and drainage leading to desiccation [44].

Acidification from ammonia emissions has caused the displacement of local flora by species that flourish in acid and nitrogen rich conditions. In addition, groundwater depletion and farmland drainage have led to the displacement of flora that thrive in moist habitats. About 40% of native plant species require wet environments [5]. The reduction in pesticides, however, appears to be easing threats to birds, worms and aquatic species, but pollution from heavy metals and pathogens remains a concern for aquatic ecosystems [5].

Changes to agricultural habitats have also adversely impacted on wild species, especially the conversion of farmland to urban use, and of pasture to arable and permanent crops. Around 7% of farmland is semi-natural habitat, mainly extensive grasslands, heaths and marshes [14], while there has been an increase in fallow land rising to over 1% of total farmland. Uncultivated habitats account for a 3% share of agricultural land, mainly woodland (> 5 ha) and small water bodies. Uncultivated habitats also provide a linear network of wet and dry ditches and hedgerows [14, 45].

As the major land user farming determines, to a great extent, the appearance of cultural landscapes. The government retains responsibility for 20 "national landscapes" covering about a quarter of the total national land area [1]. In most cases pasture is the main form of land use in these areas. The commitment to protect landscapes has been reconfirmed in several government plans. While some landscapes are still intact, many are in danger of losing their unique character, particularly open cultivated grassland on peat soils [5, 14].

3.19.3. Overall agri-environmental performance

Overall agriculture is slowly moving toward a more environmentally sustainable path, but at a considerable environmental and financial cost [5]. Environmental pressure has largely become decoupled from the rise in farm production, but the intensity of farming across the country, however, remains high by OECD standards. Agriculture is the major contributor to eutrophication, acidification, and groundwater depletion. It is a source of continuing pressure on the pollution of surface and groundwater from nutrients, pathogens and heavy metals; and on biodiversity.

An extensive environmental monitoring system has been established, which also covers agricultural pressures on the environment. Monitoring and evaluation efforts are important in tracking national progress toward the targets established under the NEPPs; and also the numerous international environmental agreements ratified by the Netherlands. The *Dutch Soil Quality Monitoring Network* started in 1993 to collect data on soil biodiversity. Initial results show some declines for nematodes in intensive pastures [13, 46]. However, information on biodiversity in relation to farming, especially on trends and the quality of semi-natural and uncultivated habitats [45] and landscapes is poor. Also there are few estimates of the costs and environmental benefits of nutrient policies [47].

Strengthening of agri-environmental policy measures should further ease environmental pressures. The European Court of Justice ruled in 2003 that the methodology of the MINAS system did not comply with the EU *Nitrates Directive*, and in response the government implemented a new nutrient policy from January 2006. Under the new policy nutrient application standards, determined by crop and soil types, comply with the EU *Nitrates Directive* [3, 4]. Decreasing application standards should lower nutrient losses to the environment, with the standards set for 2009 seeking to achieve a maximum of 50 mg nitrate per litre in upper groundwater and the standards for 2015 aiming to have an equilibrium level of phosphate fertilisation [48]. A target to reduce pesticides by 95% by 2010 compared with 1998 (pesticide use stabilised between 2000 and 2004 [23]) will be addressed by greater adoption of integrated pest management; stricter regulations on pesticide sales and use; improved farmer education; and farm certification [3, 5].

In 2005 the government introduced a habitat approach into biodiversity policy with a specific focus on an integrated area, rather than the earlier approach of conservation plans for each species [49]. The *Policy Document on Organic Agriculture 2005-07* aims for 10% of

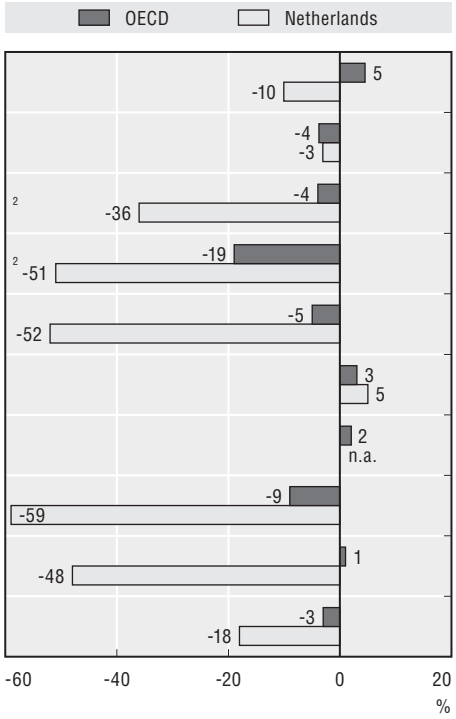
farmland to be under organic production by 2010. The growth in conversion of land to organic farming slowed between 1999 to 2004, and accounted for around 2.5% of farmland in 2002-04 [50]. Payments provided for 5 years for organic conversion and maintenance were phased out from 2005, with instead a system whereby certification costs for the period 2006-10 are be paid under the EU *Rural Development Programme* [1, 50, 51].

Moving agriculture onto a sustainable path will remain a major challenge. Currently more than half of Dutch dairy farms apply more than 250 kg nitrogen per hectare (kg N/ha) through the application of livestock manure to grassland [47]. The EU *Nitrate Directive*, however, stipulates a maximum of 170 kg N/ha from livestock manure, but the EU agreed to grant the Netherlands a derogation of 250 kg N/ha, which the new nutrient policy aims to meet over the next 5-10 years [52]. In addition, a further reduction of nutrient loadings into the North Sea will be necessary to achieve the *OSPAR Convention* target of 2010. While EU and international targets have been met for ammonia emission reduction, and are likely to be met up to 2010, these emissions need to be further reduced in order to prevent harm to natural habitats [1]. The accumulation of phosphorus in farmed soils and the build up of agricultural pathogens and heavy metals may affect water quality for many decades to come [5]. For groundwater the farm tax exemption reduces the incentive for farmers to use surface water, with only around 2% of them paying the national tax and many avoiding payment of the provincial tax [8, 18, 30].

Meeting government targets by 2010 for pesticide use and the area organically farmed will require a substantial effort over the second half of this decade in view of the limited progress to date. Improving energy efficiency in the horticultural sector may require containing the increase in area of greenhouse cultivation under artificial lighting [32]. But subsidising energy use by greenhouse operators, and on-farm diesel use, acts as a disincentive to improving energy use efficiency and reducing GHG emissions. To date, efforts to slow or reverse agriculture's pressure on biodiversity have had little success, possibly due to the fact that the intensity of farming has counteracted the effects of agri-environmental measures, as revealed by, for example, the poor state of meadow birds and the decline in the area of land under on-farm conservation schemes by private landowners [41, 42]. The government is committed to halting biodiversity loss by 2010 [49], with payments to farmers being increased to meet the 2010 target of around 5% (110 000 ha) of agricultural land being managed as semi-natural habitat [5].

Figure 3.19.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

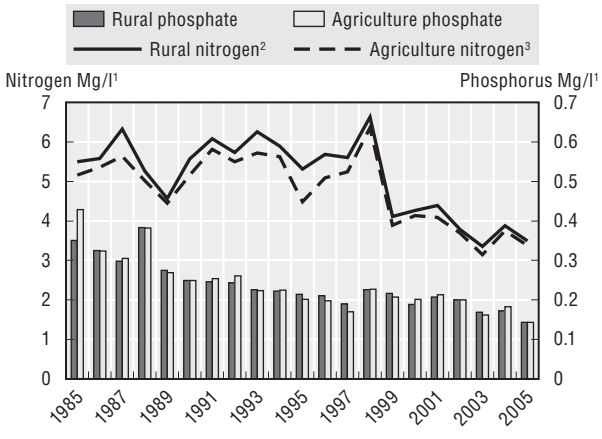
Variable	Unit		Netherlands	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	90	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–61	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	229	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	19	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–9 283	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+175	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	n.a.	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	0.1	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–113	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–4 100	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

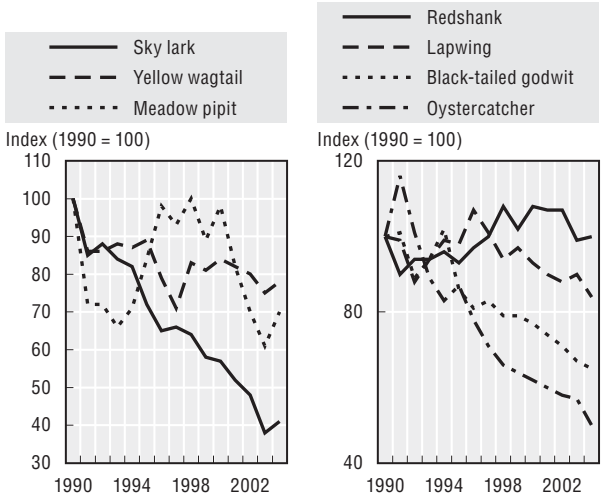
Figure 3.19.3. **Annual mean concentrations of nitrogen and phosphorus in surface water of rural and agricultural water catchments**



1. Maximum tolerable risk for nitrogen 2.2 mg N/l and 0.15 mg P/l for phoshorus in surface water.
2. 75% of rural upstream catchments including agricultural and other effluents.
3. 75% of agricultural upstream catchments.

Source: RIZA Institute for Inland Water Management and Waste Water Treatment, 2007.

Figure 3.19.4. **Farmland bird populations**



Source: NEM (SOVON, CBS, provinces).

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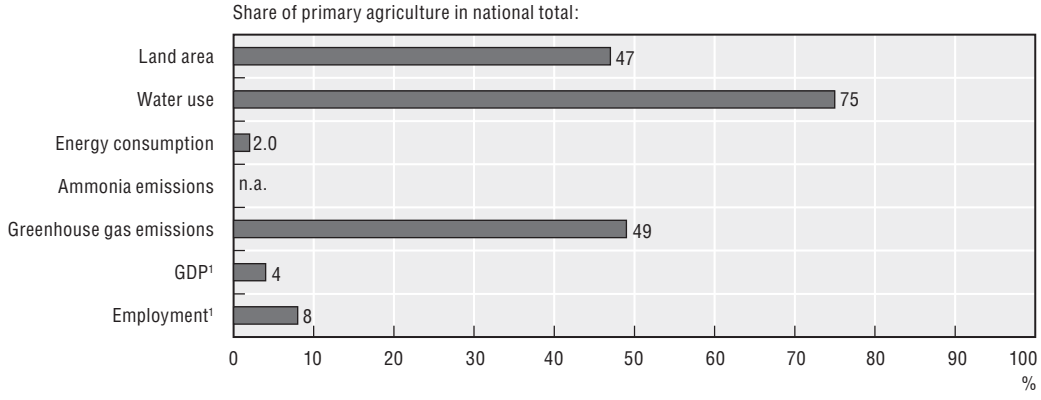
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3.20. NEW ZEALAND

Figure 3.20.1. **National agri-environmental and economic profile, 2002-04: New Zealand**



StatLink http://dx.doi.org/10.1787/300760536460

1. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.20.1. Agricultural sector trends and policy context

The agricultural sector is important to the New Zealand economy. It contributes about 4% to GDP and 8% to employment, while farm exports accounted for over 50% of the value of merchandise exports in 2004 [1] (Figure 3.20.1).

Agriculture has undergone substantial structural change over the past 20 years, since the government's commitments to economic liberalisation, including the removal of most agricultural support. The farming sector has responded with further diversification, the area under horticulture and vines rose by over 20% and forestry plantations by 40%; and intensification, with some sectors (dairy) relying on greater use of inputs (*e.g.* fertilisers) to increase production, and others (horticulture) focusing on raising value and quality [2]. As a result, the volume of agricultural production grew by 38% over the period 1990-92 to 2002-04 on a declining area of farmland (–3%) (Figure 3.20.2). Also the use of purchased farm inputs (volume) grew more rapidly than output, revealing the intensification of production over the same period, with inorganic nitrogen and phosphate fertiliser use rising by around 420% and 100% respectively; direct on-farm energy consumption 22%; but pesticide use by only 4% (Figure 3.20.2) [3, 4, 5, 6]. Overall this has resulted in improvements over 1985 to 2006 compared to 1972 to 1984 (numbers in brackets), in the total output per annum; input productivity; and factor productivity, by 1.7% (1.1%), 1.9% (0.2%), and 3.1% (–0.5%) respectively [7].

Support to agriculture is the lowest in the OECD. Producer support fell from a peak of over 30% of farm receipts in the mid-1980s to 2% in 2002-04 (as measured by the OECD's Producer Support Estimate) compared to the OECD average of 30% [8]. Support to agriculture is mainly directed at research, pest and disease control, agri-environmental

measures and climatic disaster relief. Budgetary expenditure on agri-environmental measures has grown from about NZD 80 (USD 50) million in 1997 to almost NZD 100 (USD 60) million by 2004 or around 15% of total agricultural support [8, 9].

A range of policy instruments are used by government to achieve agri-environmental objectives [9]. Almost 90% of government agri-environmental budgetary expenditure is provided for research and education, such as the *Public Good Science and Technology Fund* [9]. The *Sustainable Farming Fund* (SFF, established in 2000), has seen an increase in funding for projects up to 2009 at around NZD 10 (USD 6) million annually. SFF projects seek to transfer information and technology from experts to primary producers in order to improve the financial and environmental performance of agriculture and forestry [8, 10]. In 2003 a *Dairying and Clean Streams Accord* was agreed between Fonterra (a private company controlling over 95% of New Zealand's milk supply), the Ministries of Agriculture and Environment, and regional councils, to work together to improve water quality in dairying areas by using voluntary guidance and information tools, such as the adoption of nutrient budgeting [8].

Agriculture is affected by national and international environmental policies. The ***national environmental policy framework*** affecting agriculture is characterised by decentralisation of decision-making and devolution of responsibility to 74 territorial authorities and 12 regional councils. Authorities charge farmers in order to recover the costs associated with programmes and applications, while responsibility for resource management remains with the farmers [7]. Three nationwide overarching policies address environmental concerns: the *Resource Management Act* (RMA, 1991); the *Hazardous Substances and New Organisms Act* (HSNO, 1996); and the *Biosecurity Act* 1993. The RMA integrates measures governing resource management, and its key themes are: sustaining the potential of natural and physical resources; safeguarding the quality of soil, water, air, and ecosystems; and avoiding, remedying or mitigating adverse effects on the environment. With respect to water, while use permits are issued under the RMA through regional councils, there is no direct government funding for irrigation development and farmers pay the full recovery costs for water [11]. The HSNO aims to protect the environment by preventing and managing the adverse effects of hazardous substances, including pesticides and new organisms not currently present in New Zealand. The *Biosecurity Act* is designed to systematically protect the nation's biological system – introduced and indigenous – from the harmful effects of pests and diseases. Farming is also affected by New Zealand's commitments under ***international environmental agreements*** including eliminating the use of methyl bromide (an ozone depleting substance) under the *Montreal Protocol*; safeguarding biodiversity under the *Convention on Biological Diversity*; and reducing greenhouse gas emissions under the UNFCCC and its *Kyoto Protocol*.

3.20.2. Environmental performance of agriculture

The key environmental challenges concerning the agricultural sector include: soil management, water quality, biodiversity and climate change. Pesticide and energy use and the growing demand for water for irrigation are also important. Agriculture dominates land and water use, accounting for 47% of total land use and around 75% of water use. While the area under grazing, arable fodder and fallow land has declined over the 1990s, there has been rapid growth in the area under horticulture, but its share of the agricultural land area is only 1%. With the first Polynesian settlement, but especially since European settlement from the mid-19th century, the establishment of agriculture initiated dramatic

deforestation and impacts on indigenous wildlife. A combination of temperate climate and youthful geology have resulted in "natural" soil erosion rates ten times the world average in some locations, and high average annual yields of soil sediment loss to the ocean [2, 12].

Soil quality has come under pressure from overgrazing [1]. A 2004 assessment of soil quality indicates that about 80% of agricultural land fell within target ranges identified as desirable to maintain soil quality for production and environmental objectives [13]. Overall, however, soil erosion (water and wind) is not a significant issue, mainly because over 75% of farmland is permanent pasture. About 5% of farmland is estimated to suffer moderate to severe rates of erosion (11 tonnes and above of soil loss/hectare/year), but there are no time series data available to assess trends. However, research suggests that soil erosion and loss of organic carbon have been reduced on steep pasture areas, mainly through reversion to forestry and improved management within pastoral systems [13].

Under cropping soils, loss of organic matter; severe degradation and compaction, are still concerns despite the relatively small area involved [13]. The annual expenditure on mitigating soil erosion was estimated in 2002 at NZD 26 (USD 12) million [14], while the annual cost of soil erosion (including agriculture and natural sources) was estimated in 1998 at NZD 127 (USD 68) million [2]. Localised build-up of nitrogen and phosphate under dairy pastures with the potential to pollute water bodies, *i.e.* rivers, lakes, groundwater and coastal waters, is a growing issue [13]. Streams draining catchments with pasture have been estimated to contain 2.5 to 7 times more sediment, phosphorus and nitrogen than streams draining forest catchments [5].

Agriculture, especially since the mid-1990s, has led to deteriorating water quality. Some rivers in farming areas, particularly those flowing through lowland pastoral land, fail to meet environmental water guidelines, while shallow aquifers in dairying and horticultural areas have elevated nitrate levels [2]. Overall, the quality of water bodies is high by international standards, but it is hard to identify trends due to the lack of a national water quality monitoring network [15]. Intensive farming practices are seen as increasing pressure on water quality, especially as urban discharges are being controlled [16]. Nutrients (nitrogen and phosphorus) are the main pollutants of water bodies, but there are concerns in some areas over water pollution from microbial contaminants and soil sediments.

Agricultural nutrient surpluses have risen substantially over the past decade, but surpluses per hectare of farmland are about half the OECD average for nitrogen balance surplus, but slightly above the average for phosphorus (Figure 3.20.2). Between 1990-92 and 2002-04, the increase in tonnes of nutrient surplus (input minus output) has been most marked for phosphorus at nearly 130% compared to nitrogen rising by over 40%. The main reason for the rise in nutrient surpluses over the past decade is that nutrient inputs (mainly inorganic fertiliser use) have grown much more rapidly than nutrient outputs, and the reduction in pasture area (*i.e.* lowering nutrient uptake). The nitrogen content of livestock manure, 95% of which is deposited onto pastures, rose by almost 25% (in terms of tonnes of nitrogen) between 1990-92 and 2002-04 (largely due to the reduction in sheep numbers being more than offset by the growth in cattle numbers). Over the same period inorganic nitrogen fertiliser use increased by over 420%. Dairy farming is the major user of nitrogen fertilisers and accounts for much of the growth in its use, especially for increasing rates of pasture growth [2, 5]. These developments have resulted in increased nitrogen and phosphorus pollution of some rivers and lakes, such as Lake Taupo, a UNESCO *World Heritage Site* [17], and in intensive farming regions such as Waikato and Canterbury.

Farming is estimated to contribute 75% of total nitrogen input to surface water [2], with this share likely rising as other sources of nitrogen pollution (*e.g.* urban sources) are controlled [5]. Over the 2000-03 period less than 30% of dairy farms were using a formal nutrient management plan and regularly testing the soil for nutrient levels [18], but these shares have increased since then. In parts of a few intensively farmed areas, such as Canterbury and Waikato, concentration of nitrate in groundwater exceeds the maximum allowable value for drinking water [2, 19]. There are also localised concerns with microbial pollution from livestock farming (*e.g.* faecal coliforms and *campylobacter*) of water bodies [2, 20, 21], leading to some cases of human infections above reported levels in other OECD countries [15].

While there was a small increase in pesticide use over the past decade the intensity of use is low by OECD standards (Figure 3.20.2). This is because of the dominance of pastoral farming and a limited arable crop and horticultural sector [22]. The trend in pesticide use was variable over the period 1994 to 2003 with about 13% of pesticide use accounted for by the forestry sector, although the current quality of pesticide use (sales) data are poor [23]. Between 1995 and 1998 pesticide use fell, probably due to various initiatives in the horticultural sector to reduce and use pesticides more efficiently (*e.g.* KiwiGreen). From 1999 to 2004 the use of pesticides grew by 27%, but only in 2002 and 2003 did usage surpass the levels of the early 1990s.

The growth in pesticides over this period was in part due to higher viticulture plantings [23]. While horticulture is the most intensive user of pesticides, over 13 kg of active ingredients (a.i.) per hectare (kg a.i./ha) compared to less than 3 kg a.i./ha for other users (*e.g.* arable and pastoral), it is also the most progressive in adopting practices to limit usage and damage to human health and the environment (Figure 3.20.3) [23, 24]. Even so, over the 2000-03 period only 10% of the total arable and permanent crop area was under integrated pest management [18], and the area farmed under certified organic practices was less than 0.5% of the total area farmed in 2003. The monitoring of pesticide residues in water and food indicates pollution is a rare occurrence and contamination levels are very low [24], although there is no regular monitoring of pesticides in water bodies [4].

Demand for irrigation water by the agricultural sector is growing rapidly. Agriculture uses less than 1% of available water resources, but accounts for 75% of total water use, of which nearly 80% is used for irrigation. Over 40% of water used for irrigation is derived from groundwater [2]. But, there are regions where water is becoming scarce through changes in supply and demand patterns, especially the Canterbury region where 70% of the total irrigated area is located. This is leading to growing competition between farming and other water users, and concerns over the maintenance of environmental flows to protect aquatic ecosystems, and for social and cultural values associated with water [2, 11, 16, 25].

The area irrigated almost doubled over the period 1990-92 to 2001-03 with two-thirds of it pasture. While only 4% of total area farmed is irrigated (2001-03), produce from irrigated land accounted for over 10% of agriculture GDP and 12% of farm export value in 2002/03 [11]. Projections indicate that the rapid expansion in agricultural water demand is likely to continue, especially with the expected growth in the dairy and horticultural sectors, and with climate change. Demand for irrigation water is projected to rise by nearly 30% between 2000 and 2010 [2, 26]. Around 40-50% of the irrigated area is under less efficient water application systems, but the horticultural sector is increasingly using micro/drip irrigation systems [11]. A survey also revealed that only 10-12% of irrigators regularly measure soil moisture [2].

Agricultural air emissions are significant in terms of the environmental pressure from greenhouse gases, but less so for ammonia and methyl bromide. While data on agricultural ammonia emissions are limited, what information is available suggests that the critical threshold level for damage to ecosystems is unlikely to be exceeded [27]. New Zealand has agreed, as a signatory to the *Montreal Protocol*, to phase out its use of ***methyl bromide*** by 2005, and by 2004 it was reduced by over 80% compared to 1991 levels. In 2005 "Critical Use Exemption" (CUE), which under the Protocol allows farmers more time to find substitutes, was agreed for up to 24 tonnes (ozone depleting potential), with only strawberry growers seeking to continue use under CUE status [28].

New Zealand is unique among OECD countries in that agriculture is a key sector in national climate change mitigation policy. The sector contributed 49% of total greenhouse gas (GHG) emissions (average 2002-04), with the main sources of emissions originating from livestock (methane). However, there has been a change in the emissions profile due to expansion in dairy and contraction in sheep numbers, while there has also been a large increase in nitrogen fertiliser use, mainly on dairy farms [29]. The growth in agricultural emissions over the period 1990-92 to 2002-04 (14%) was among the highest across the OECD (–3%) (Figure 3.20.2), but slightly below the rate of emission growth for the New Zealand economy (19%), although well above the nation's 0% commitment by 2008-12 under the *Kyoto Protocol*. New Zealand farm emissions, however, contributed only 3% to total OECD agricultural GHG emissions, and enteric methane emissions from dairy cattle per litre of milk per annum declined between 1990 and 2004 (Figure 3.20.4).

Projections suggest that agricultural GHGs will continue to grow up to 2010 but at a slower rate than over the 1990s [29]. While agriculture's capacity to ***sequester carbon*** in soils appears to have declined [13], the conversion of pasture to forestry has led to a net removal of CO_2 through forest sinks. Improvements in energy efficiency in agriculture can also help reduce or lower the rate of GHG emissions, although CO_2 emissions from fossil fuel combustion in farming are only a small share of total agricultural GHGs. ***Direct on-farm energy consumption*** grew substantially less (22%) than the increase in farm production volume (38%), over the period 1990-92 to 2002-04, suggesting an increase in on-farm energy efficiency. Dairy farming, for example, used 1% less direct energy in 2002 than it did in 1996 [2], despite the considerable increase in average production per hectare [30].

New Zealand has been identified as a "biodiversity hotspot" because of the uniqueness of its wild species [31, 32]. Trends in ***agricultural genetic resources*** show that extensive *in situ* conservation is taking place for crops, but that it is under pressure from non-native animals and plant pests. A large part of native flora is represented in *ex situ* collections, but information exchange between collections is poor [18]. For livestock genetic resources there is little information [18].

Overall conservation of wild species and ecosystems has shown mixed results over the past decade, with the decline of many native species and habitats being halted through preservation, improved management, and restoration [33]. Assessing the impact of agriculture on ecosystems and species is difficult because of a lack of data and monitoring [4], and because the interactions between farming and ecosystems are complex. While the quantity of indigenous woody vegetation is increasing with the contraction in the area under pastoral farming, there are signs that the quality of these habitats continues to deteriorate [32]. Also, the intensity and frequency of grazing of natural grasslands affects vegetation cover and the balance of dominant species.

Some farmers have entered into open space covenants through the Queen Elizabeth 2nd National Trust, a non-governmental organisation [31]. The *Trust* provides limited support to protect certain areas of farmers land while they retain ownership. Currently under 0.5% of farmland is included under the covenants. In some areas, elevated nutrient loadings of rivers and lakes from livestock have had adverse impacts on aquatic ecosystems [31]. But in some regions, however, where riparian management programmes are used, water quality has remained stable or improved, even though stock numbers have increased. In the case of the Taranaki region, for example, cow numbers doubled over the past 20 years while most water quality indicators remained the same or improved over this period [34].

3.20.3. Overall agri-environmental performance

New Zealand has a high degree of dependence on its biological assets for generating much of the nation's wealth. Levels of "natural" soil erosion for most land in the country are above the global average. Increasing climatic instability is heightening risks and costs for farmers, and is focusing attention on water resources in some drier regions. Biodiversity conservation is a challenge for farmers, but agriculture also incurs significant costs and threats associated with invasive species.

OECD projections from 2006 to 2015 indicate a continued expansion in farm production, but at a lower rate of growth than over the period 1990-2005 [35]. Higher farm output is most likely to derive from improvements in productivity rather than an extension of the area farmed or greater livestock numbers [35]. For example, the projected rise in milk production of 1.7%/annum (2006-15), in contrast to 4.4%/annum over the period 1990-2005, is expected to result mainly from raising dairy cow yields (1.2%/annum) compared to higher cow numbers (0.5%/annum).

A key impediment to adequately assessing environmental performance in agriculture is the limited availability of nationally comparable data. With the projected expansion in the agricultural sector up to 2015 [35], this heightens the widely recognised need for an improved monitoring system [2, 4] to provide a baseline for tracking the state and trends of: soil [36, 37, 38]; water [15]; biodiversity resources [32]; pesticides [23, 24]; and energy use in agriculture [30]. However, New Zealand uses indicators and other quantitative data extensively in agri-environmental policy assessment, and recently instituted a *Linked Indicator Project*, which examines a range of economic, social, cultural and environmental measures significant to communities and their well-being. These indicators will provide information to support the monitoring and reporting requirements of local authorities, and will cover both urban and rural councils. The project aims to include measures of: energy use, water use, land use and cover, economic and industry activity, as well as a range of standard of living indicators.

Policy changes and voluntary actions by farmers over the past decade suggest the future prospects of reducing agriculture's pressure on the environment are encouraging. After a phase of uncertainty following the comprehensive economic and political reforms in the 1980s, a process of stakeholder consultation, outreach and education across the agro-food sector [39], reinforced by the *Resource Management Act*, has led to growing use of environmental farm plans and farmer investment to address environmental issues [3, 40]. While the uptake of these plans by dairy farmers was initially low [39], the number of plans developed by farmers is increasing.

The 2003 agreement between the dairy industry and the government (Dairying and Clean Streams Accord) to address environmental issues, is a promising development [15, 41]. In 2004, national and local governments have agreed to fund a total package of nearly NZD 82 (USD 54) million that is intended to limit nutrient flows from agriculture into Lake Taupo, such as restrictions on land use and allowing nitrogen trading to occur [8, 16]. Research indicates that to maintain current water quality in the Lake will require a 20% reduction in nitrogen from farming and urban areas [2].

***The government has notified the strawberry industry that after 2007 it will no longer seek Critical Use Exemption of methyl bromide, under the* Montreal Protocol**. This development which should see the end of the use of this ozone depleting substance in New Zealand [28].

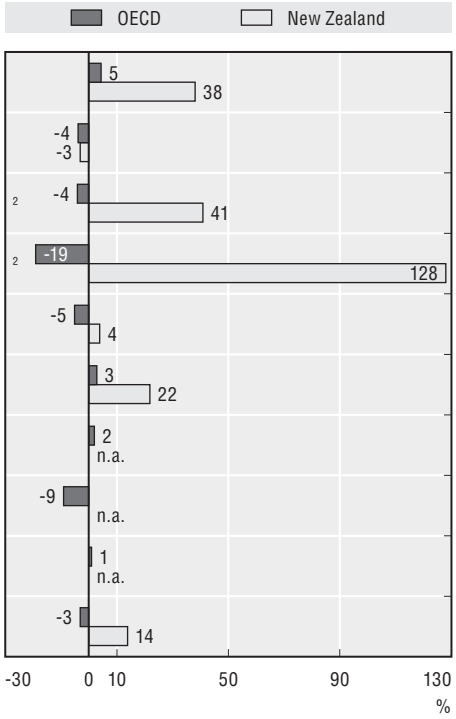
Biosecurity programmes seek to benefit productive farming and forestry systems by controlling or eradicating various pests, which may also help to enhance biodiversity conservation and bring other environmental benefits. For example, the increasingly widespread threat to nitrogen fixation in clover pasture (which accounts for over 50% of the nitrogen inputs into agriculture) from the clover root weevil (*Sitona lepidus*) may encourage farmers to use greater nitrogen fertiliser applications [2].

Overall the quality of the environment impacted by agriculture is high but there are areas of concern, especially given the projected growth in the agricultural sector over the next decade. The agricultural policy reforms from 1984 reduced environmental pressure on marginal land, especially soil erosion, and encouraged forestation and reversion to native bush. Over the 1990s up to 2004 there has been a significant intensification of agriculture, especially dairying, and further diversification, such as into deer farming, horticulture and forestry [2]. This has led, in particular, to elevated levels of nutrients in soils and water bodies, growth in direct on-farm energy consumption, and higher emissions of greenhouse gases from agriculture. Despite the growing demand for water by irrigators in certain regions where scarcity and competition are increasing, there has been little strategic consideration of regional water resources to provide incentives to invest in water or encourage irrigators to use water more efficiently. The government, however, is currently examining the water allocation system under the *Water Programme of Action* [2, 11, 16, 42, 43].

There are many initiatives to encourage greater adoption of environmentally beneficial farm management practices. Moreover, rates of adoption of environmental farm management practices have grown rapidly over the past decade [2], but overall adoption rates remain low. Over the 2000-03 period, for example, less than 30% of dairy farms were using a formal nutrient management plan and regularly testing the soil for nutrient levels, 10% of the total arable and permanent crop area was under integrated pest management [18], and only 10-12% of irrigators regularly monitor soil moisture content [2]. But a joint government and agriculture greenhouse gas research strategy was developed in 2003 to seek to lower emissions [8].

Figure 3.20.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

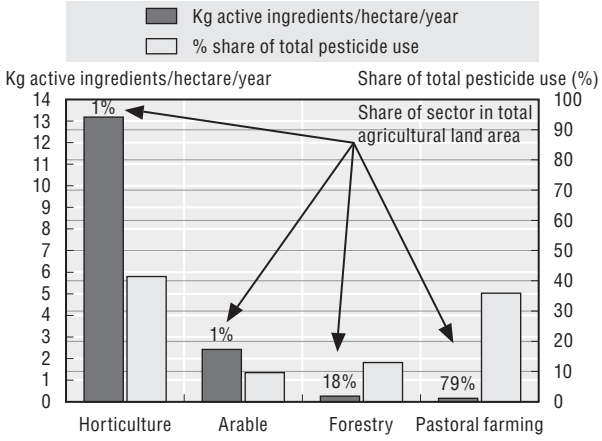
Variable	Unit		New Zealand	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	138	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–396	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	46	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	14	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	+150	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+57	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	n.a.	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	n.a.	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	n.a.	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	+4 668	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

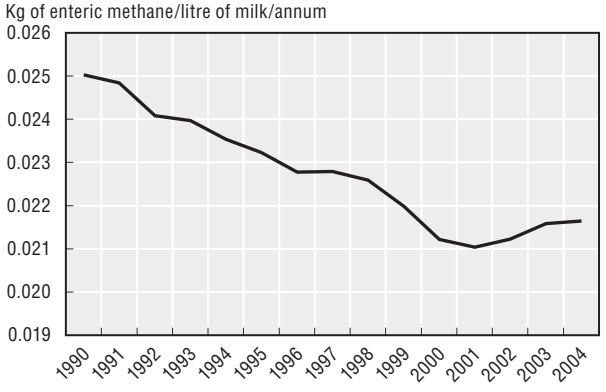
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.20.3. **Sectoral use of pesticides: 2004**



Source: Ministry for the Environment, New Zealand.

Figure 3.20.4. **Dairy cattle enteric methane emissions per litre of milk**



Source: The National Inventory Report and Common Reporting Format: New Zealand's Greenhouse Gas Inventory 1990-2004 and New Zealand's Greenhouse Gas Inventory 1990-2005.

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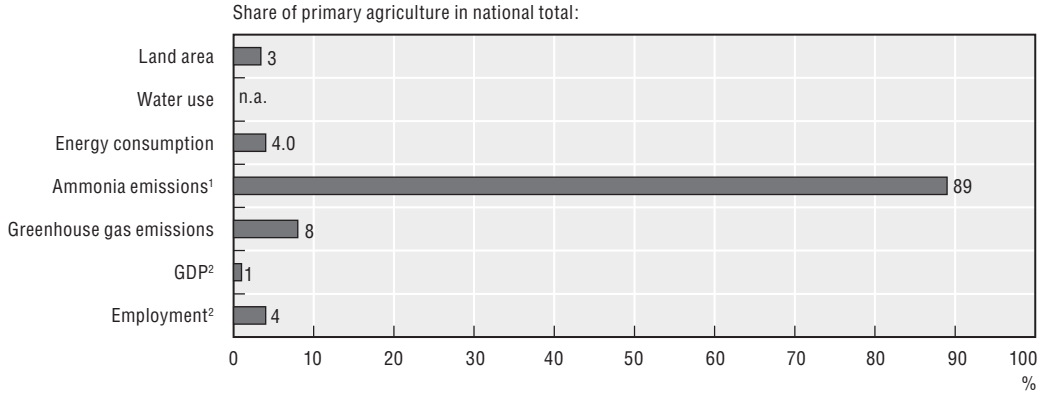
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3.21. NORWAY

Figure 3.21.1. **National agri-environmental and economic profile, 2002-04: Norway**



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1. Data refer to the year 2001-03.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.21.1. Agricultural sector trends and policy context

Agriculture is a small sector in the economy, with its share of GDP and total employment at under 1% and 4% respectively in 2004 [1] (Figure 3.21.1). While the volume of farm production remained stable between 1990 to 1997, it then declined by about 2% to 2004, largely reflecting a drop in livestock output [2]. Chemical input use has declined more rapidly than farm output suggesting production intensity is diminishing, with the volume of purchased farm input use decreasing between 1990-92 and 2002-04 by around 6% and 17% for nitrogen and phosphate inorganic fertilisers respectively, 26% for pesticides (1990-2003). Direct on-farm energy consumption rose by over 24% (Figure 3.21.2), however, this number should be used with caution because of uncertainties in the data series.

Norway is one of a few OECD countries where the area farmed increased by 4% from 1990-92 to 2002-04. This largely reflects the growth in the area under pasture, partly offset by a reduction in the arable and permanent crop area [1]. Some of the apparent increase in area farmed was due to improved registration and reporting by farmers due to the transition from a farm support system based on production to one based on area. Another reason for the growth in agricultural land is related to stricter requirements with regards to the minimum area for manure spreading [3]. The share of farmland in the total area is the lowest across OECD countries at around 3% in 2002-04, because of limits to cultivation due to topography, climate and the length of the growing season [1]. Cereal production dominates the lowlands in eastern and central areas, while grassland, mainly for dairy, accounts for much of the remaining farmland [3].

Agricultural support remains high compared to the OECD average. Support to farmers (as measured by the Producer Support Estimate) has on average remained unchanged at around 70% of farm receipts between 1986-88 and 2002-04, while the OECD average decreased from 37% to 30%. The share of output and input linked support, still accounts for 72% of the PSE in 2002-04, although it has fallen from almost 90% in 1986-88. Border measures and budgetary payments to farmers including area, headage, and deficiency payments are the main policy instruments supporting agriculture. A significant proportion of these payments are differentiated by region and farm size [4]. Total agricultural budgetary support was nearly NOK 11 (USD 1.6) billion in 2004 [1, 4].

Greater policy attention is being given to agri-environmental concerns. Over the 1990s, area-based payments under the *Acreage and Cultural Landscape Programme* were provided on the condition that farmers employ environmentally friendly production methods. Expenditure on this programme in 2003 accounted for about NOK 3 (USD 440 million) billion or one quarter of total budgetary support to farmers. In 2003, the programme was separated into two: the *Cultural Landscape Programme*, under which all farmers complying with environmental requirements receive a per hectare payment; and the *Acreage Support Programme* which provides payments to less-favoured areas, encouraging certain crops and providing support to small farmers. For farmers who do not meet the environmental requirements under these programmes, a penalty is imposed of between NOK 8 000 to 18 000 (USD 1 200-2 700) per farm according to the area farmed. Since 1990, support has also been provided to organic farming. The government's goal is that 15% of total food production and food consumption should be organic in 2015. By the end of 2005, 4.2% of total agricultural land was under organic practices, and organic products constitute about 1% of total food sales.

Agriculture is also impacted by a range of national environmental and taxation measures. As part of its environmental taxation policy taxes have been applied to farm chemicals [5]. A tax on mineral fertilisers introduced in 1988 (NOK 1.2/kg nitrogen, NOK 2.3/kg phosphorus, USD 0.15 and 0.30, respectively) was abolished in 1999, to reduce the associated costs for farmers, and replaced by compulsory nutrient management planning and a whole farm management plan. Pesticides were first subject to a tax in 1988, which was subsequently increased up to 15.5% of the wholesale price in 1996 [6, 7]. As a follow up to the *National Action Plan for Risk Reduction* (1998-2002), a new area-based tax system was implemented in 1999. A base rate of NOK 20 (USD 2.4) per hectare was multiplied with a factor for each tax class. The tax classes were differentiated according to environmental and health risks. The tax per kg or litre of product was calculated by using a standardised area dose for each product. The base rate for the pesticide tax was raised to NOK 25/ hectare in 2005 (USD 2.5-3.2), providing an annual revenue of about NOK 100 (USD 15) million [4, 5]. Farmers benefit from a fuel tax concession which amount to over NOK 310 (USD 40) million of tax revenue forgone annually over 2002-04 [4, 8]. Biofuels (and biofuel/diesel mixes) are exempt from the fuel and the carbon dioxide (climate change) taxes [9]. Since 2003 a bioenergy programme provides financing to promote bioenergy heat production from agricultural and forestry biomass [10].

Agriculture is also impacted under international environmental agreements, including Norwegian commitments to lower nutrient emissions into the North Sea (*OSPAR Convention*), ammonia emissions (*Gothenburg Protocol*), methyl bromide (*Montreal Protocol*) and greenhouse gases (*Kyoto Protocol*). A target has also been set to halt the loss of all biodiversity by 2010 to meet commitments under the *Convention of Biological Diversity* [5, 11].

3.21.2. Environmental performance of agriculture

Agriculture plays an important role in terms of the protection of cultural landscapes and biodiversity. There is public concern over the conversion of arable land for urban use and conversion of marginal farmland with a high nature and landscape value to scrub or forestry. In response the government aims to half the loss of biodiversity by 2010, maintain landscapes and public access to them, and halve the annual conversion of high quality arable land to other uses by 2010 [11]. National targets (from all sources including agriculture) have also been set for the discharge of nutrients into the North Sea to be reduced by 50% by 2005 from a 1985 base year, and annual ammonia emissions should not exceed 23 000 tonnes as from 2010 [11]. As agriculture is largely rain-fed, its use of water resources is small [3]. Irrigation is very limited, mainly used in vegetable and potato production, and covered around 4% of the total agricultural land area in 2004, however, farmers have the capacity, in terms of equipment, to irrigate 11% of the total agricultural area.

The share of farmland subject to a medium to high risk of soil erosion declined over the 1990s, from around a third of the total area down to a quarter [2]. Similarly the share of agricultural land in the very high soil erosion risk class (> 8 tonnes/hectare) fell from 3% to 1% over the past decade [2]. Soil erosion is largely an issue in the south-eastern area of the country, mainly land under cereal production and in the cases where fields are ploughed in autumn [3, 12, 13, 14]. To a large extent the improvement in reducing soil erosion rates has been linked to an increase in the share of the cereal area not tilled between harvesting and spring, rising from about 20% in the early 1990s to nearly 45% by 2002-04 [3]. Payments were introduced for no autumn tillage in 1991, and increased by 2001 to NOK 580-1 670 (USD 65-185) per hectare depending on erosion risk [12], with all the no-tilled area receiving a payment by 2002-04 [3]. Sediment load to water bodies has also been reduced through payments to develop sedimentation ponds and riparian buffer zones which were expanded over the 1990s [12, 13]. The reduction in soil erosion rates, and improvements in tillage and crop residue management practices, has led to an increase in the soil organic carbon content of agricultural soils [14].

Agriculture remains a major source of water pollution. Due to a coastal climate, the low share of agricultural land and low population density in Norway the vast proportion of freshwater resources are of high quality. For water bodies in more central areas the overall drinking and environmental water quality has been improving since 1990, but still remains a problem for both surface and coastal waters in the main agricultural areas [3, 5, 11, 15]. While some agricultural water pollutants have declined since 1990 (inorganic fertilisers and pesticides), the increase in livestock numbers, and resultant growth in manure, has increased the risks of nitrogen and phosphorus pollution of water bodies from manure.

Agriculture is the major source of eutrophication in surface waters in some agricultural areas and coastal waters. With most point sources of nutrient pollution of water (*e.g.* urban sources) having been reduced significantly, agricultural non-point pollution sources are now the main source of pollution in many cases [5, 16]. Even so, nutrient surpluses (input minus output of nutrients, nitrogen and phosphorus) declined over the period 1990 to 2004, both in absolute terms and per hectare of agricultural land (Figure 3.21.2). Much of the reduction in surpluses has been due to lower fertiliser use and the near stable uptake of nutrients by crop and pasture. However, this has to some extent been offset by an increase in nutrient inputs from livestock manure due to growing livestock numbers,

notably pigs and poultry, although cattle and sheep numbers remained largely unchanged, with a decline in the national dairy herd. Eutrophication is a particular problem where much of the surrounding land is under agriculture, such as in South-Eastern Norway [11].

The decline in nitrogen surpluses, however, led to a small reduction in nitrate concentrations in surface waters of predominantly agricultural and forestry catchments over the period 1991 to 2002, although phosphorus concentrations have risen, reflecting the long time lags involved with phosphorus transport into water [17]. Agriculture accounted for respectively 56% and 47% of total nitrogen and phosphorus inputs into Norwegian *coastal waters* (North Sea) in 2002, although since 1985 surplus agricultural nitrogen flowing into coastal waters declined by 28% with a reduction of 38% for phosphorus [3]. The share of farms and agricultural land under a nutrient management plan rose over the 1990s and from 1999 became compulsory [2]. During the period of the fertiliser tax, 1988 to 1999, the volume of nitrogen fertiliser use showed little change but declined slightly from 2000 to 2004, while for phosphorus use declined significantly from 1988 to 1999 but since 2000 has remained stable.

Pesticide sales decreased by 26% from 1990-92 to 2001-03 (volume terms of active ingredients), among the largest rate of reduction across OECD countries (Figures 3.21.2 and 3.21.3) [3]. The trend in pesticide sales, however, has shown considerable annual variability over this period. Much of the variation was explained by farmers stockpiling pesticides prior to expected government increases in pesticide taxes, such as in 1998 and at the end of 1999, after which pesticide sales fell by around a half in 2000 and 2001, recovering again in 2002 [7]. Pesticides are applied to about a third of farmland, mainly cereals and horticultural crops, as only 6% of harvested grassland and pasture was sprayed, with the average number of treatments per year ranging from around 1 for pasture to over 9 times for apples [18]. Human health and environmental risk indicators reveal that from 1996 to 2000 pesticide sales fell by 8% but the risk indicators declined by over 30%, although from 2000 to 2003, the sales and risk indicators both rose. These results, however, have to be treated with caution, especially because of the recent stockpiling of pesticides by farmers [7].

Nearly all surface water monitoring sites in agricultural areas detected the presence of one or more pesticide compounds, although the share was much lower for groundwater at over 25% between 1995 and 2002 [2, 19]. For surface water the frequency of pesticide detection, concentrations and environmental risk for the majority of pesticide compounds declined over the period 1996 to 2000 [20]. Monitoring of pesticides in groundwater has not been as extensive as for surface water as it only provides around 10% of drinking water supplies [2, 6]. Pesticides have been detected in 50% of farm drinking wells that have been monitored, with 30% of the wells with concentrations above drinking water standards [2]. As a consequence of the greater adoption of low or no tillage practices to reduce soil erosion on land growing cereals, this has led to an increase in pesticide use. From 1992/93 to 2001/02 over 40% of cereal area was sprayed for couch grass (*Elymus repens*) on which there was no tillage, compared to under 20% of the cereal area ploughed in autumn [3].

Air pollution from agriculture is stable or declining. The trend in agricultural ***ammonia emissions*** overall remained stable over the period 1990-92 to 2001-03 (compared to a 7% reduction for the EU15), although did rise slightly between 1990 to 1996 and then declined (Figure 3.21.2) [21]. The main sources of agricultural ammonia emissions are livestock (nearly 90%), the use of fertilisers and treatment of straw with ammonia [3]. Agriculture

contributed to 88% of ammonia emissions in 2004, but around 15% of total acidifying substances in 2003, and while ammonia emissions have changed little over the past decade, their share in acidifying substances has risen because of the greater reduction in sulphur dioxide emissions by other sectors [3]. Under the *Gothenburg Protocol* Norway has agreed to an ammonia emissions ceiling of 23 000 tonnes by 2010, which was the level reached in 2001-03 [11]. The share of the total land area where critical loads for acidification were exceeded declined from around 20% in 1990 to below 15% in 2000 [21]. But, in southern Norway common plant species have declined probably due to acid rain, however, agriculture is a minor source of acid rain as Norway is a downstream country for acid rain from the United Kingdom and Central and Eastern Europe [22].

By 2003 Norway had exceeded its commitment to reduce methyl bromide use (an ozone depleting substance) by 70% under the *Montreal Protocol* with a decrease of nearly 80% from the 1991 base year. While many OECD countries have applied for exemptions on using methyl bromide, as they are unable to meet the requirement for a total phase out by 2005, Norway has not done so [23].

Agricultural greenhouse gas (GHG) emissions decreased by 3% over the period 1990-92 to 2002-04, compared to a reduction of 7% for the EU15 (Figure 3.21.2) [10]. Farming contributed about 8% of total Norwegian GHG emissions in 2002-04, while its commitment under the *Kyoto Protocol* is an increase of total GHGs of 1% from the 1990 base year by 2008-12. In 2003, agriculture was the most important source of nitrous oxide, about 50% of total emissions, and accounted for around 40% of methane emissions, with agricultural GHGs mainly derived from livestock and the use of fertilisers [10]. Projections indicate a slight reduction in agricultural GHGs up to 2010 [10].

Direct on-farm energy consumption grew by 24% between 1990-92 to 2002-04, compared to an increase of 4% across all OECD countries and a 17% rise in total Norwegian energy consumption, even though farming only accounts for 4% of total energy consumption. But data on agricultural energy consumption should be used with caution because of uncertainties in the data series. The production of ***bioenergy***, heat and fuel, from agricultural biomass provides under 1% of total energy consumption, although the potential exists to increase this share [9].

Agriculture continues to exert pressure on biodiversity but there are recent signs that the pressure could be easing, especially with low nutrient surpluses and pesticide use, although information on agri-biodiversity is poor. There is little information on the trends and state of ***agricultural genetic resources*** (crops and livestock), but there are plans for national management of genetic resources in agriculture [11]. A programme was started in 2003 to document crop genetic resources [24], and all endangered breeds of livestock are under a conservation programme, and there are also extensive *ex situ* collections of livestock genetic material [2].

For wild species about 3% of indigenous plants species and about 10% of bird species are endangered by the intensification in agricultural areas [5]. For vascular plant species there appears, however, to be considerable regional variation in species richness and abundance depending on the structure of the agricultural landscape and intensity of land use [25]. There is also evidence in some localities (Finnmark) of lichen cover decreasing from 1987 to 2000 as a result of overgrazing by reindeer [26]. Farmland bird populations showed a downward trend over the 1996 to 2003 period, markedly so for the Skylark (*Alauda arvensis*)

and Curlew (*Numeniusarquata*) [27]. There are signs, however, of some stability and even increase in numbers of certain bird species associated with farming since the mid-1990s, including the Northern Lapwing (*Vanellus vanellus*) and Barn Swallow (*Hirundo rustica*) [27].

Several conflicting trends in agricultural land use and structure are affecting biodiversity, as well as farmed cultural landscapes, which makes it difficult to measure the overall change. These include further concentration of farming in the fertile south-east; conversion of farmland to scrub or forestry in some marginal areas (*e.g.* Hjartdal); conversion of forest to farmland in other regions (*e.g.* Rogaland) [3, 5, 11, 28]; the loss of small habitat features on farmland, including ponds and water meadows [28]; and an increase in the area under pasture while the arable crop area has declined (Figure 3.21.4).

Farming provides cultural landscape amenity, but there are concerns over the deterioration in its quality and conversion to other landscape forms [11]. As much of the total land area is forested and alpine mountains, farmland covers only 3% of the land area, maintaining an "open" farmed landscape is considered important given demands for outdoor recreation and agri-tourism [11, 29, 30]. The *Norwegian Monitoring Programme for Agricultural Landscapes*, the so-called 3Q programme started in 1998 and conducted on a 5-year inventory cycle, has few results to date to draw any clear conclusions as to trends in farmed landscapes [31, 32, 33]. Limited evidence suggests, however, that there is a growing polarisation of farmed landscapes with an increasing uniformity of landscapes in highly intensive agricultural areas, while farmed landscapes with greater heterogeneity are being converted to forest or left to overgrowth [33, 34, 35].

3.21.3. Overall agri-environmental performance

Overall the pressure from agriculture on the environment has decreased. With the slight decline in agricultural production from 1990 to 2004, especially since 1997, and the reduction in use of fertilisers and pesticides, and with an increase in the total agricultural area, the intensity of agriculture has diminished (Figure 3.21.2). This has brought a lowering of environmental pressure, as revealed through the decrease in nutrient surpluses, environmental pesticide risk indicators, and stable or declining air emissions from agriculture. Despite these improvements agriculture remains a major source of water pollution and farming activities continue to threaten biodiversity especially from abandonment of farmed land, but also from an increase in the homogeneity of farmed landscapes.

There is an extensive environmental monitoring system, which includes tracking the impact of agriculture. The *Agricultural Environmental Monitoring Programme* (JOVA) measures numerous variables from 8 selected water catchments; health and environmental pesticide risk indicators are being used to track the *Action Plan* on pesticides; and for agricultural landscapes the *Norwegian Monitoring Programme for Agricultural Landscapes* has since 1998 started to develop an inventory of landscape changes. Some areas of agri-environmental monitoring require strengthening notably biodiversity, but also agricultural ammonia emissions [9]. The Government plans to further expand environmental monitoring and research programmes [11], including for pesticides [6]. Statistics Norway delivers an annual report of statistics concerning environmental measures in agriculture [36].

There has been a shift toward greater use of agri-environmental measures and some environmental targets have been met. The recent shift in emphasis from agricultural price support to area based payments on condition that farmers employ environmentally friendly production methods have to some extent reduced the policy incentive for intensive

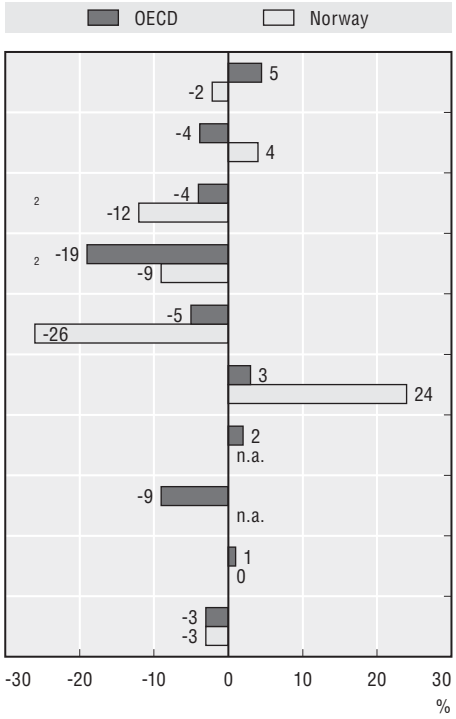
production [4]. However, the most production distorting policies still account for the largest share of support (over 70%) to agricultural producers [4]. The use of environmental taxes on fertilisers (although ended in 1999) and pesticides are consistent with the polluter-pays-principle, while for pesticides the decision to sharpen the focus of the tax on the most harmful compounds should enhance the effectiveness of the measure [4, 7].

The goal to further reduce health and environmental risks from pesticide use has been extended under the *Action Plan for Pesticide Risk Reduction* with a reduction target of 25% for the period 2004-08, and a total reduction target of 50% over the period 1998 to 2008 [6]. For methyl bromide the government is close to meeting the complete phase out by 2005 [3]. The *National Environmental Programme* was introduced in 2004 to better coordinate a range of agri-environmental payments provided over the 1990s, with the objective of protecting cultural landscapes and heritage, biodiversity, reducing pollution, and increasing public access to the countryside. Under the programme all farmers are required to establish an environmental plan, such as maintaining a checklist of the environmental situation and performance of the farm and a map indicating cultural monuments and valuable landscape features. The programme also provides a greater role for 18 regional administrations, with about NOK 350 (USD 52) million in 2005 and NOK 390 (USD 61) million in 2006 available for environmental measures based on regional priorities [1, 4].

Despite progress in reducing agricultural pressures on the environment a number of concerns remain. While the government's target to reduce nutrient discharges (including from agriculture) into the North Sea (by 50% compared to 1985 levels), has been met for phosphorus (a 66% reduction), the reduction of 40% for nitrogen by 2004 indicates that further effort will be required to achieve the target [5. 11, 17]. There are still challenges regarding phosphorus in some freshwater bodies, and they are being targeted through Norway's implementation of the *Water Framework Directive* [37]. The target to halt the loss of biodiversity by 2010 will also require further action in agriculture, mostly regarding the loss of agricultural land and livestock grazing to shrub and overgrowth, but also due to intensive agriculture in some regions. With a slight increase in ammonia emissions over the 1990s, the 2010 *Gothenburg Protocol* target was already reached by 2003, but projections suggest that agricultural ammonia emissions are likely to remain stable up to 2010 [21]. While energy taxes are used widely across the economy to meet environmental objectives, farmers are provided a concession on these taxes which acts as disincentive to limit on-farm energy use, improve energy efficiency and further reduce GHG emissions. There is also potential to make greater use of agricultural biomass to further increase renewable energy production for heating [9].

Figure 3.21.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

Variable	Unit		Norway	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	98	105
Agricultural land area	000 hectares	1990-92 to 2002-04	40	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	77	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	13	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–236	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+155	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	n.a.	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	n.a.	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	+0	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–147	–30 462

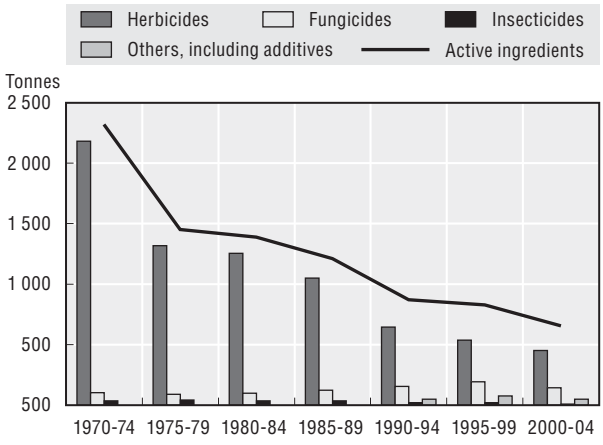
n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions, the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.21.3. **National sales of pesticides**

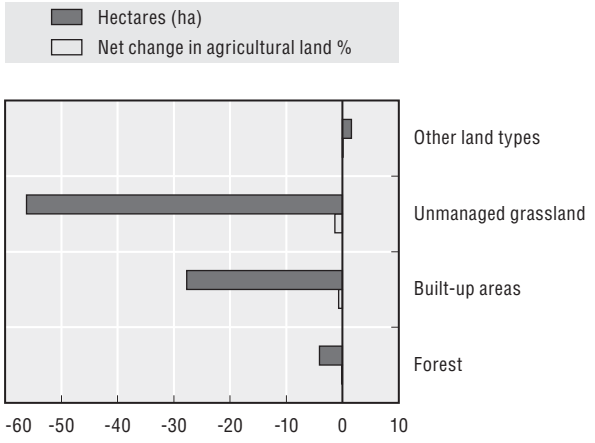
Tonnes of active ingredients



Source: Statistics Norway (2005), Natural Resources and the Environment 2004, Oslo, Norway, *www.sst.no/english*.

Figure 3.21.4. **Net change in agricultural land for five counties**

1998-2004



Source: Norwegian Forest and Landscape Institute.

StatLink http://dx.doi.org/10.1787/300805520350

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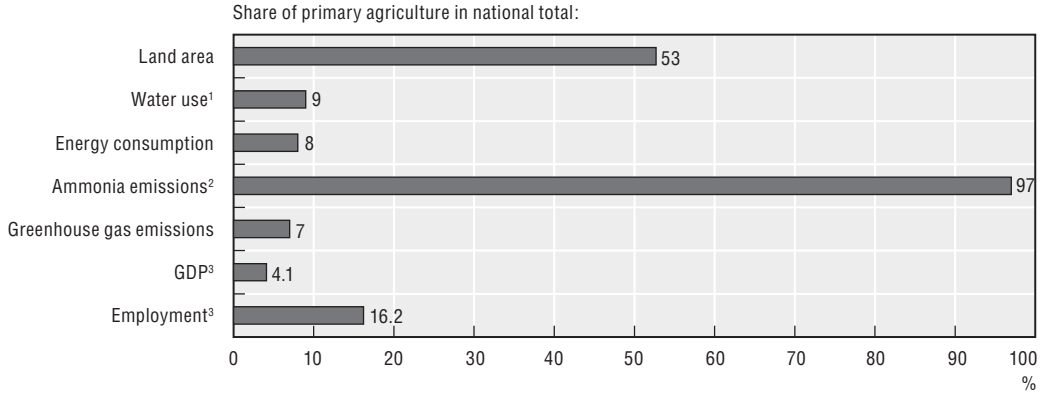
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3.22. POLAND

Figure 3.22.1. **National agri-environmental and economic profile, 2002-04: Poland**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2001.
3. Data refer to the year 2005.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.22.1. Agricultural sector trends and policy context

Agriculture plays a key role in providing employment in the national economy, but that role has shrunk considerably over the period since 1989. The share of agriculture in total employment was 16.2% in 2005 compared to 26.4% in 1989, but the decline in agriculture's contribution to GDP has been even more significant from 12.8% in 1989 to 4.1% in 2005 [1, 2, 3, 4, 5] (Figure 3.22.1).

The volume of agricultural production decreased by 5% over the period 1990-92 to 2002-04 (Figure 3.22.2), among the largest reductions across OECD countries (Figure 3.22.2). But in the recent period 2000 to 2006 production has begun to stabilise and even increase for some commodities, both in value and volume terms, notably for pig and poultry products [2, 3, 6]. Trends for purchased farm input use (volume terms) over the period 1990-92 to 2002-04, however, have been variable, decreasing for nitrogen (–2%) and phosphorus (–32%) inorganic fertilisers, as well as for agricultural water use (–31%), but increasing for pesticides (52%) and direct on-farm energy consumption (29%) (Figure 3.22.2). Although the use of farm inputs stabilised and even began to rise slightly from the late 1990s, by 2005 they still remained below their peak of the middle to late 1980s [3].

Transition from a centrally planned to a market economy has impacted significantly on agriculture, since the early 1990s. The fundamental change in political and social institutions as well as economic conditions has affected how land use decisions are made and led to extensive changes in farm ownership patterns, productivity and competitiveness [7, 8, 9, 10, 11, 12]. Contrary to many other centrally planned economies in

Central and Eastern Europe, Poland was never fully collectivised and many small private individual farms prevailed [4, 13]. The most salient trend in farm structures over the transition period has been the increasing fragmentation of the farm structure with a growing number of small subsistence and semi-subsistence farms (1 to 10 hectares), which has arisen mainly because of a lack of other employment options. There has also been a small increase in the number of large farms (over 20 hectares) which in 2005 accounted for about 4.5% of all farms but more than 40% of farmland largely in the western part of Poland [1, 2, 4, 10, 14, 15]. Agricultural productivity (as measured by total factor productivity indices) declined over the period from the early 1990s to the early 2000s, with estimates varying at an average annual decline of between –2% to –4%, the lowest across OECD countries [10, 13, 15, 16, 17]. This decline reflects the transition to a market economy in terms of the poor profitability and structural problems of farming over the past 15 years, such as low levels of education and capital investment (although investment rose between 1990 and 2005), but also a lack of any significant adjustment in farm employment in contrast to the much sharper reduction in the sector's share in GDP [1, 14, 15].

Farming is now supported under the Common Agricultural Policy (CAP), with support also provided through national expenditure within the CAP framework. Support to agriculture has fluctuated considerably over the past 20 years. Due to the implementation of economic reforms, support declined from around 40% of farm receipts (as measured by the OECD Producer Support Estimate – PSE) in the mid-1980s to a negative PSE in 1990 (*i.e.* farmers were implicitly taxed as domestic prices were lower than world market prices), but then gradually rose to 13% by 2001-03, as policies were geared toward EU membership in 2004. For Poland support under the CAP started in 2004. During Poland's preparation for EU membership, Polish agriculture benefited from funds allocated under the pre-accession policies (see below). Measures taken under these policies will be continued in accordance with the *Rural Development Plan* (RDP) for 2004-06. The EU15 PSE was 34% in 2002-04 compared to the 31% OECD average [4, 7, 18]. Nearly 70% of EU15 support to farmers was output and input linked in 2002-04, the forms of support that most encourage production [7]. Total annual budgetary support to Polish agriculture was almost PLN 15 (EUR 4.6) billion for 2005, of which around 47% was nationally financed, the remainder coming from EU funding [2, 7]. Agri-environmental measures in Poland accounted for about 6.1% of budget support under the RDP [19].

Agri-environmental and environmental policy has had to address several key challenges. Firstly, policy had to respond to the environmental problems left from the legacy of the centrally planned economy; and secondly, policy responses have been required for EU accession and membership. Over much of the period of transition up to the time of EU membership agri-environmental policy was not a priority, while the government lacked resources to invest in environmental protection [4, 20, 21]. Indirectly, however, through the removal of government support for purchased farm inputs (*e.g.* fertilisers, pesticides, energy) and other production related support, this had the effect of lowering agricultural production intensity and consequently pressure on the environment. Even so some limited agri-environmental measures were introduced over the 1990s, such as the: *Green Lungs of Poland Programme* which was a voluntary agri-environmental scheme established by non-governmental organisations in the early 1990s to protect high nature value agricultural areas in north-eastern Poland; 1st *National Environmental Policy* (1991) which established some regulations to protect soils and water; *Protection of Agricultural and Forest Soil Act (1995)* and the *Nature Conservation Act* (1991), providing protection for agricultural genetic

resources [5, 22, 23]. In 2001 a strategy was developed to protect water resources against agricultural nitrate pollution and the Ministry of Agriculture and Rural Development began to offer support for agri-environmental measures at *Natura 2000* sites.

EU accession and membership from 2004 has also brought policy change. The EU provided pre-accession funds for agriculture up to 2006 (including for environmental purposes) through three programmes: *SAPARD*, the most important for agriculture in terms of funding the establishment of institutions and systems of policy implementation; *PHARE*, covering institutional building; and *ISPA*, to assist infrastructure development, including environmental protection [18, 20]. The EU accession period since 2004 has required the adoption of EU agri-environmental and environmental policies, and harmonisation of technical standards [7, 20]. Policies under the CAP are being phased in up to 2013, when CAP support will reach 100% of the EU15 level.

The National Agri-environmental Programme (NAEP), covering the initial period of EU membership is a part of the broader *Rural Development Plan* (2004-06). The NAEP, as well as promoting environmental beneficial farming practices and raising environmental awareness among farmers, has three main objectives for agriculture: protection of the environment and landscapes; development of organic farming; and conservation of biodiversity, including agricultural genetic resources [2, 3, 24]. Since 2000 the state budget has provided support for the maintenance of livestock populations covered by genetic resource protection programmes, and from 2005 the protection of livestock genetic resources has been financed under the agri-environmental programme. Funding for the NAEP amounted to PLN 782 (USD 250) million in June 2007, with two main types of measures: first, those implemented nationally, for example payments for organic farming, soil and water protection (*e.g.* payments for buffer zones) and protection of local breeds; and secondly, those implemented in terms of 69 priority zones with specific environmental problems or which possess high natural value, such as payments for the maintenance of pastures and extensive meadows [3, 24]. To comply with the *EU Nitrate Directive*, several programmes and schemes have been implemented, including designation of *Nitrate Vulnerable Zones* (covering 1.7% of the total land area in 2004), to regulate farms in terms of fertiliser and manure application and storage practices, and provide farm support investment aid for the construction of manure storage facilities [25, 26, 27, 28].

Agriculture is affected by national environmental and taxation policies. Under the *National Woodland Extension Plan*, part of the *2nd National Environmental Policy* (2000), it is planned to expand the afforestation of land unsuitable for agriculture by 680 000 hectares between 2001 to 2020, which could have important implications for flood control and climate change protection efforts [1, 5]. Farmers pay a lower rate (7%) of value added tax (the standard rate is 22%) on pesticides and fertilisers, and support was provided for lime fertilisers up to 2004 [5, 28]. From 2006 a fuel tax concession is provided to farmers, with PLN 650 (USD 209) million allocated in 2006 (*i.e.* the total tax concession available depending on the extent of tax refund claims by farmers) [19]. There are regulations to restrict the conversion of farmland to other uses in some regions [9]. General budgetary expenditure covers irrigation infrastructure improvements and management of almost PLN 50 (USD 16) million in 2006. Farmers are also exempt from water abstraction charges under the Water Law providing their total abstractions do not exceed 5 m^3 of daily abstractions from surface water and groundwater used within the farm household [4, 5, 19, 21].

Poland is a signatory to a number of international environmental agreements, some with implications for agriculture including limiting emissions of: nutrients into the Baltic Sea (*HELCOM Convention*); ammonia (*Gothenburg Protocol*); methyl bromide (*Montreal Protocol*); and greenhouse gases (*Kyoto Protocol*). Under the *National Strategic Plan for 2007-13 Rural Development* and the NAEP, there are a range of measures which contribute to reducing GHG emissions from agriculture, including: support for afforestation of farmland [2, 3]; provision of advisory services to improve fertiliser and manure application practices; and payments to develop manure storage capacity. In addition, under the guiding principles of the *Development Strategy of the Renewable Energy Sector* (2001) support is provided to farmers for renewable energy produced from agricultural biomass feedstock. These include: payments for energy crops (*e.g.* energy willow) of PLN 216 (USD 67) per hectare; support for bioenergy plant construction, such as straw and wood fired boilers, biogas systems, and capacity for biofuel production; and excise tax exemptions for biofuels, although from January 2007 these exemptions were lowered to align them with EU regulations to PLN 1.0 (USD 0.32) per litre for biodiesel and PLN 1.5 (USD 0.48) per litre for bioethanol [29, 30, 31]. As part of its commitments under the *Convention of Biological Diversity*, the *National Strategy for Conservation and Sustainable Use of Biological Diversity* (2003) through the NAEP has established programmes for conservation of agricultural genetic resources and the protection of high nature value meadows and pastures [3, 32]. Poland also has a number of bilateral and regional environmental co-operation agreements with neighbouring countries. These include some agreements important to agriculture and the environment in Poland, such as transboundary nature conservation, through the *Carpathian Convention* (2006) covering the mountains in the South [5, 32], and transboundary river pollution, linked to limiting nutrient flows into the Baltic Sea [5, 27].

3.22.2. Environmental performance of agriculture

Environmental concerns related to agriculture have changed dramatically over the past 20 years. With the reduction in farm production and purchased input support, and shift to a market economy, farming moved from an intensive production orientated system to adoption of more extensive farming methods, linked particularly to the large decrease in use of purchased farm inputs, and in some areas adoption of agri-environmental management practices. In the pre-transition period the primary agri-environmental problems were soil erosion, heavy pollution of some water bodies and poor uptake of environmentally beneficial farming practices [3, 4, 5]. Over the 1990s certain environmental problems persist, due to the legacy of decades of damaging farming practices, notably soil erosion and in some areas industrial pollution of farmed soils, especially from acidification and heavy metals [3, 4, 33]. The pressure on water and air quality, and biodiversity has eased with more extensive farming practices, but pollution continues in some regions, while land use change and cessation of farming has led to damage to biodiversity in some areas [3, 5, 33].

Soil erosion and soil acidification are major and widespread environmental problems [3, 11, 22, 33, 34]. According to assessment in 2005 about 29% of Poland's total land area is at risk of water erosion and about 28% at risk to wind erosion. In 2005 a total of about 19% of the total agricultural land area is at risk of medium to strong wind erosion, and around 28% and 13% of agricultural and forest land was at risk to medium and strong water erosion and gully erosion respectively (Figure 3.22.3) [14]. Farming areas worst affected by water erosion are mainly in the North and mountainous South East (*e.g.* Małopolskie and Lubuskie districts), while central and eastern regions are mostly

endangered by wind erosion (*e.g.* Łódzkie and Mazowieckie districts) [33]. ***Soil acidification*** in the late 1990s was estimated to be a problem on over 50% of agricultural land, and primarily originates from natural conditions, mainly unfavourable climate, soil and hydrological conditions, but also from industrial pollution [1, 3, 11]. Soil conservation practices are not widely adopted by farmers, mainly because of the lack of resources for farmers to undertake preventive measures, such as liming acidic soils and the creation of wind shields (hedges and trees) [3, 33]. The liming of soils through use of calcium fertilisers, for example, to counteract soil acidification has decreased from over 180 kg/ha of agricultural land (expressed as pure calcium) in the late 1980s to around 94 kg/ha in 2001/02 [3].

Overall water pollution from agricultural sources is not as acute as in many other OECD European countries, as the intensity of fertiliser and pesticide use, as well as livestock operations, are appreciably below those for most OECD countries [3, 5, 26]. But recent trends are mixed and in some locations inappropriate farming practices have led to pollution risks. While the intensity of nutrient surplus per hectare of agricultural are more than 50% lower than the OECD and EU15 averages (Figure 3.22.2), since the late 1990s nutrient surpluses have begun to rise after dropping sharply in the transition period from the late 1980s, with a similar development also apparent for pesticides. Although intensive cropping and livestock operations are a source of pollution, a key problem is the inadequate storage of manure on small farms and the poor uptake of environmental farm management practices on small farms that limit pollution from nutrients and pesticides [3, 4, 20, 28, 33].

There have been large reductions in agricultural nutrient surpluses (Figure 3.22.2). The trends in the intensity of nutrient surpluses per hectare of total farmland, both of nitrogen (N) and phosphorus (P), over the period from the late 1980s to 2004 fluctuated considerably. In the late 1980s nutrient surpluses were at a level comparable to those of the EU15 average, although by the early 1990s there was a sharp reduction, especially for phosphorus. From around the late 1990s while there has been a slow increase in surpluses, they were still well below the averages for the OECD and EU15 by 2002-04 (Figure 3.22.2). The reduction in support to fertilisers and crop and livestock products during the transition period largely explains the decrease in nutrient surpluses. This is highlighted by the fluctuations in the use of inorganic N fertilisers which fell from (figures in brackets are for P fertilisers) around 1 400 000 (900 000) tonnes in the late 1980s down to 650 000 (230 000) tonnes in the early 1990s, rising to about 860 000 (315 000) tonnes by 2002-04 [3].

Overall the agricultural pollution of water bodies from nutrients is generally low [21]. In 2002, 0.4% of surface water monitoring sites across the country exceeded the EU standards on nitrate in drinking water (50 mg NO_3/l) [1, 3]. But excessive eutrophication is apparent in about 50% of lakes located in agricultural water catchments, while the Ministry of Health data for 2000 estimated that 24% of farm wells had water of poor quality in excess of the EU drinking water standards [3, 5, 25]. Poland also contributes to nutrient loadings into the Baltic Sea, and is the major contributor to pollution of the Baltic [5]. Agriculture contributes about 45-50% of national nitrogen discharge and 30-35% of phosphorus discharge into the Baltic, and although the absolute level of nutrient discharge has declined since 1990, Poland's share of agricultural nutrients into the Baltic remains high compared to other Baltic states [3, 4, 5, 25].

The rising levels of nitrogen surpluses since the late 1990s, however, have increased pressure on water quality in certain areas. Some 1.7% of the total land area in 2004 was designated as *Nitrate Vulnerable Zones* (NVZs) under the EU *Nitrates Directive* [1, 25, 26, 27]. It

was estimated by the Government in 2001 that for Poland to comply with the *Nitrates Directive* (*e.g.* cost of installing manure storage facilities) would cost over PLN 12 (USD 3) billion [26, 28]. For ***phosphate*** the trend has been different since over most of the period from the early 1990s phosphate surpluses have been declining, reducing the potential pollution of water bodies. ***Heavy metal*** pollution of water from use of inorganic fertilisers and manure, is also minor mainly due to the low intensity of using fertilisers and manure surpluses compared to other OECD European countries [35]. Concentrations of heavy metals in the vast majority of Poland's soils (about 97% of the farmed area) are at a natural level or only slightly elevated [36].

In those areas suffering nutrient pollution of water from agriculture this is predominantly associated with small farms. About 50% of farms in 2000 had storage facilities for manure and only 4% had liquid manure tanks with sufficient capacity for four months of manure production, while this is obligatory in NVZs [3, 25]. Moreover, there are low rates of uptake of nutrient management plans or soil nutrient testing. These problems are partly linked to farmers' lack of capital to invest in manure storage and other manure treatment technologies; and also to inadequate knowledge of nutrient management practices [27]. Poland has also suffered the historic legacy that prior to 1990 investment in manure storage systems was not a priority [27].

The increase in pesticide use was among the highest across OECD countries from 1990-92 to 2001-03, but the trend has fluctuated considerably over this period (Figure 3.22.2). Pesticide use declined from around 12 000 tonnes (of active ingredients) in the mid/late 1980s to around 7 000 tonnes by the early/mid-1990s, then rose to nearly 10 000 tonnes by 2002-04 [3]. The reduction in support to pesticides and crops during the transition period explains much of the decrease in pesticides use in the early 1990s [4]. The more recent growth in pesticide use is largely linked to the expansion in cereals and horticultural production, and the use of pesticides to help raise crop yields taking into account that pesticide application rates are considerably lower than many other OECD European countries [2, 3, 5, 6]. To a limited extent the growth in pesticide use has been restricted with the expansion in ***organic farming***, with more than half of the total organic area under arable and horticultural crops in 2002 [2]. Even though organic farming grew rapidly over the 1990s, by 2003-05 it only accounted for 0.6% of agricultural land compared to the EU15 average of nearly 4% [2, 14, 37, 38].

With the growth in pesticide use since the mid-1990s the pressure on water quality has been increased, although there is little information on pesticide concentrations in surface and groundwater. The highly persistent DDT pesticides, which were banned from use at the end of the 1970's, were detected in rivers and the Baltic Sea up to 2000, at levels below limits harmful to human health but of some concern for their impact on aquatic ecosystems [39]. There are also concerns for environmental pollution from inadequate pesticide application technologies and inappropriate storage and waste disposal [4].

As agriculture is largely rain-fed use of irrigation is limited accounting for 0.6% of the total farmland area in 2003 [14]. Farming's share in national water use was 9% in 2001-03, although agricultural water use declined by over 30% between 1990 and 2003 (compared to an 18% reduction for national water use), largely because of the sharp reduction in irrigation water use [5]. Particular concerns related to agriculture and water resources are: the limited capacity of on-farm water storage facilities, which does not provide adequate protection against periodic floods and droughts; and also lowering of groundwater levels in some rural areas [1, 4, 6].

There has been a major reduction in air pollution linked to agriculture. Agricultural ***ammonia emissions*** decreased by –22% between 1990-92 and 2001, among the largest reductions across OECD countries (Figure 3.22.2) [3]. Farming accounted for nearly all ammonia emissions in 2001, with the drop in emission levels mainly due to the decrease in livestock numbers and nitrogen fertiliser use. With total ammonia emissions falling to 326 000 tonnes by 2001 [6], Poland has already achieved its 2010 target of 468 000 tonnes required under the *Gothenburg Protocol* [5]. Further reductions in ammonia emissions could be achieved if poor manure storage and fertiliser spreading practices were improved [33]. For ***methyl bromide*** use (an ozone depleting substance) Poland reduced its use between 1991 to 2003 by 70% as agreed by the phase-out schedule under the *Montreal Protocol* which sought this level of reduction by 2003 and to eliminate all use by 2005. But Poland, together with a number of other OECD countries, was granted a "*Critical Use Exemption*" for 2005 (equivalent to over 20% of 1991 levels) which effectively gives more time for users to develop alternatives.

Agricultural greenhouse gas (GHG) emissions rose by 4% from 1990-92 to 2002-04 (Figure 3.22.2). However, there were considerable annual fluctuations in agricultural GHG emissions over this period and by 2004 emissions (nearly 34 million tonnes of CO_2 equivalent) were below the level of the late 1980s (50 million tonnes of CO_2 equivalent tonnes) [29]. This compares to an overall decrease across the economy of 21% from 1990-92 to 2002-04, and a commitment under the *Kyoto Protocol* to reduce total emissions by 6% over 2008-12 compared to 1990 levels. Agriculture's share of national total GHGs was 7% by 2002-04. Much of the rise in agricultural GHGs was due to the recent growth in livestock numbers (raising methane emissions), higher fertiliser use (increasing nitrous oxide emissions) and greater use of energy. Projections suggest that agricultural GHG emissions could stabilise in the period from 2005 to 2008-12, as a result of an expected decrease in cattle production offset by a rise in crop, pig and poultry production [29, 40]. This implies that agricultural GHG emissions by 2008-12 could remain at around 30% below the level of the late 1980s [29].

Agriculture has contributed to higher GHG emissions by increasing direct on-farm energy consumption, partly offset by agricultural GHG carbon sinks from expanding renewable energy production and developing afforestation of agricultural land. ***Direct on-farm energy consumption*** rose by 29% between 1990-92 and 2002-04 compared to a reduction of 4% for total national energy consumption, with farming contributing 8% of total energy consumption (Figure 3.22.2). The growth in agricultural energy consumption is largely explained by the substitution of farm labour for machinery, with farm employment declining by around 20% between 1990-92 and 2001-03 compared to an increase in the number of farm tractors by nearly 9% (26% increase in terms of average tractor power) over the period 1995 to 2005 [14].

While production of renewable energy from agricultural and other biomass feedstocks is growing, it provides only about 4% of total primary energy supply in 2006 [29, 30, 41, 42]. Agricultural biomass feedstocks are mainly used for: *heating*, about 450 local thermal power stations and 250 000 biomass heated boilers in farm dwellings of around 5 000 Megawatts were established between 2001 and 2004; and for *liquid fuel* production (biodiesel and bioethanol), mainly from molasses, low quality cereals, potatoes and other agricultural products [29, 30]. Biofuel production was estimated at 113 million litres of bioethanol and 72 000 tonnes of methyl esters used in biofuels annually in 2005 [29, 42]. There is considerable potential to expand current biomass feedstocks, especially from short rotation farm forestry [30, 41], but to achieve the government's biofuel goal of 5.75%

share of total transportation fuel by 2010 would require a significant increase in production from current levels [43]. Of the 20 agricultural biogas plants that were installed in the 1980s only one is currently in operation [29].

Agricultural carbon sequestration has been affected by two main developments. First, the 16% decrease in the area under permanent pasture over the period 1990 to 2004 has likely led to a reduction in soil organic carbon, and second, the afforestation of farmland under various government schemes is probably increasing carbon sequestration. Under the *National Woodland Extension Programme*, for example, 111 300 hectares of farmland were converted to forestry between 1995 and 2000, which was under 1% of the total agricultural land area [3].

Poland is widely perceived to have a rich biodiversity in agricultural areas, compared to many other OECD European countries [1, 3, 33]. But pressure on biodiversity from agricultural activities is becoming more evident, although evaluating the effects of farming on biodiversity since 1990 is complex [3, 4]. Unlike many other centrally planned economies the lack of farm collectivisation lowered pressure on biodiversity [8], while over the early to mid-1990s threats to biodiversity diminished, especially with the reduction in use of fertilisers and pesticides. Since the mid/late 1990s, however, there has been some intensification of agricultural (*e.g.* higher pesticide use), while the fragmentation of farms into a growing number of small and semi-subsistence units has led to the poor uptake of farming practices to help biodiversity and low investment in environmental protection (*e.g.* manure storage). However, the fragmentation of farm holdings has contributed to a mosaic landscape structure, to the benefit of biodiversity by providing a greater diversity of habitats.

Protection of agricultural genetic resources is being addressed through* in situ *programmes and* ex situ *collections of genetic material [3, 33, 44]. The number of registered plant varieties has risen steadily with 917 varieties registered by the Research Centre for Cultivar Testing in 2000. Between 1986 and 1995, between 30-32 varieties were registered every year, whereas in 2006 the number increased to 47 varieties annually [44]. But the shift toward monoculture and less complex rotations since 1990 has possibly diminished crop plant diversity and, although information is incomplete, evidence suggests the genetic erosion of plant resources over recent decades [3, 44]. Even so, some 300-400 plant genetic materials are added to the national plant gene bank annually [32]. For livestock, 32 programmes were implemented in 2002 for the conservation of livestock genetic resources, covering 75 breeds, varieties and sub-species of livestock and fish [44]. *In situ* and *ex situ* livestock conservation programmes were introduced from 1999 and since this period the National Coordination Centre for Animal Genetic Resources has been monitoring the size of livestock breeding populations [3, 32].

A major share of agricultural land is designated as having a high nature value, and with 53% (2002-04) of the total land area farmed this has important implications for biodiversity [3, 33, 45]. There is a great diversity of habitats on agricultural land. Around 50% of meadows and pastures are classified as semi-natural (about 10% of total farmland), which include wet meadows and other important wetland habitats. Also farmland comprises over 40% of national protected landscapes (which cover around a quarter of the total land area) in 2002 [3, 46]. The main threats to the high nature value agricultural habitats are: their conversion to forestry and urban use; their shift to more intensive forms of management (*i.e.* higher fertiliser and pesticide use); and in some marginal areas their abandonment to overgrowth where it may be too costly to convert them to cropland or forestry [11, 33]. The nearly 12% reduction in area farmed between 1990-92 and 2002-04

was among the highest across OECD countries, with a decrease in arable and permanent crop land by 11% and permanent pasture by 16% over this period. Nearly 18% of farmland was estimated to be idled or abandoned in 2002, with this share rising to over 30% in some regions (*e.g.* Lubuskie, Podkarpacie,Śląsk) [1, 3]. The overgrowth of grazed wet meadows is considered to be one of the most serious threats to open wetlands [46].

An important area of semi-natural grasslands and cultural farmed landscapes is in the Carpathians, a mountainous region extending over 7 European countries. This includes the Tatra mountains in south eastern Poland, which is recognised as a UNESCO *Biosphere Reserve* since 1996 [5, 32, 47]. These grasslands are considered to be among the most species rich in Europe with many protected plant species, such as those belonging to the orchid family [23, 48]. But their continued existence is coming under a variety of threats, especially the increase in the area under fallow and the drastic reduction in livestock over the 1990s, especially the sheep flock. This has led to the abandonment of some semi-natural grasslands or for others under grazing below a level necessary to maintain the plant species richness of the grasslands [47, 48]. The Carpathians also have significance for Poland (and other bordering countries) in terms of their cultural landscape value, in particular, associated with transhumance shepherding [49]. The major decline in extensive sheep production since the early 1990s, however, has led to the disappearance of shepherding tracks and historic mountain shepherd huts to the detriment of the cultural landscape [49].

The extensive farming system in many parts of the country has been beneficial to wild species conservation. With the extensive nature of farming practices and diverse habitat structures in most rural areas, this is providing favourable conditions for many wild species of flora and fauna [3]. But the abandonment of farmland in some areas and intensification and removal of habitat features in others is increasing pressure on wild species, although monitoring of wild species, especially related to farming activities, is only beginning to be established [1, 3]. An estimated 2.2% of vascular ***wild plant species*** occurring in Poland are endangered or threatened as a result of the cessation of grazing and mowing practices; ploughing grassland; and the use of fertilisers and pesticides [3]. Research has shown that ***grassland butterflies*** in southern Poland are also subject to similar threats as plant species [50]. Even so, most ***game species*** have recovered in numbers since 1995, such as the various species of deer, bears, wild boars, foxes and moose, but a few populations have declined markedly, such as hares and partridges [6]. Wolf numbers, a wholly protected species in Poland (the largest population in Europe), have also increased.

Over the short period farmland bird populations have been monitored (2000-04), the population index has declined slightly (Figure 3.22.4) [1]. But Poland was considered to have had relatively stable farmland bird populations over recent decades [51]. The decline in farmland bird numbers is of concern as farming was estimated to have posed a threat to around 25% of important bird habitats through changes in management practices and land use in the late 1990s [52]. Moreover, Poland, is host to major remaining populations of many of Europe's endangered farmland bird species, such as the Corncrake (*Crex crex*), Corn Bunting (*Miliaria calandra*), Whinchat (*Saxicola rubetra*), Aquatic Warbler (*Acrocephalus paludicola*), White Stork (*Ciconia ciconia*) and Orotlan Bunting (*Emberiza hortulana*) [3, 53]. Recent research suggests that abandonment of farmland has been a major influence on bird populations, but with both negative and positive impacts on bird species and

populations [53, 54, 55]. In addition, intensification of farming and removal of habitat features has had adverse impacts on bird populations. For some other farmland bird species, such as the Little Owl (*Athene noctua*), the cause of their decline is unclear [56].

3.22.3. Overall agri-environmental performance

Overall agricultural pressure on the environment has been low since 1990, compared to that in many OECD countries [5]. The agricultural system is largely characterised by small and semi-subsistence farms especially in the Eastern part of the country, as Poland was never fully collectivised pre-1990. These farms use a low intensity of purchased farm inputs (*e.g.* fertilisers, pesticides, energy and water) and have a diversity of habitats across the agricultural landscape [5]. Although the use of farm inputs stabilised and even began to rise slightly from the late 1990s, by 2005 they still remained below their peak of the middle to late 1980s [3]. But the rising levels of agricultural nutrient surpluses and pesticides since the late 1990s have increased pressure on water quality. Moreover, soil erosion and soil acidification are major and widespread environmental problems associated with farming activities. Also declines in farmland bird populations and changes in land management practices have raised concerns with respect to agriculture's impact on biodiversity.

While improvements are being made to agri-environmental monitoring many data gaps remain, which need to be addressed if policy makers are to be provided with the information required to effectively monitor and evaluate agri-environmental performance and policies. Agriculture plays only a limited role in the environmental protection monitoring activities of the *Unit of Environmental Monitoring* of the *Chief Inspectorate of Environment Protection* (GIOS) [33]. Data related to soil degradation are only available from surveys conducted in the late 1990s and there are no time series data available nor information on soil conservation practices [22]. More quantitative data on erosion processes at the catchment level are needed to support policy and management schemes aimed to combat erosion [22]. It is not possible to adequately assess the extent of water pollution from agriculture as there is no national water monitoring system for farm pollutant sources of rivers, lakes, groundwater, and coastal waters although projects financed by PHARE are seeking to improve the monitoring system. Similarly the extent of agri-biodiversity monitoring is still too limited [43], but from 2000 the monitoring of farmland bird populations was established.

Agri-environmental policies have been strengthened in the period since EU membership, but the low level of environmental awareness of farmers is an impediment to the success of these policies. The *National Agri-environmental Plan* (NAEP), part of the broader *Rural Development Plan*, is placing particular emphasis on environmental protection, especially lowering water and air pollution, development of organic farming, and biodiversity conservation [2, 3, 24]. A serious barrier to meeting the higher environmental standards required under these agri-environmental programmes and other EU and international environmental policies, however, is the low level of environmental awareness among farmers [3]. The large number of small holdings, their weak financial base, coupled with low educational standards, are obstacles to meeting agri-environmental policy objectives [3]. According to recent research only 30% of farmers are aware of the potential detrimental impact of their activities on the environment, while there is a chronic lack of investment in the necessary facilities (*e.g.* manure storage tanks) and equipment (*e.g* manure spreaders) that could bring environmental improvements [3]. Also farmers have stocks of obsolete capital (*e.g.* old machinery) that impede environmental and production efficiency gains [16].

Despite the relatively low environmental pressure of the farming sector, a number of concerns remain. Given the lack of ***manure storage*** facilities and uptake on nutrient management plans, a considerable effort will be required for Poland to comply with the EU *Nitrate Directive* and meet Poland's *HELCOM* commitments to limit nutrient pollution of the Baltic Sea [28]. While nutrient run-off into the Baltic has been significantly reduced and measures adopted to address the problem, Poland still contributes the major share of nutrient inputs from agriculture into the Baltic. This reflects not only the progress of other Baltic countries in reducing their nutrient inputs, but also that Poland has a greater share of arable land and population than other Baltic countries [5].

There has been success in lowering the use of methyl bromide use over the 1990s, but a further reduction in use will be required if Poland is to phase out use completely as agreed under the *Montreal Protocol*. But granting *Critical Use Exemptions*, to give farmers additional time to find methyl bromide substitutes, may impede the effectiveness of achieving reduction targets and act as a disincentive to finding alternatives.

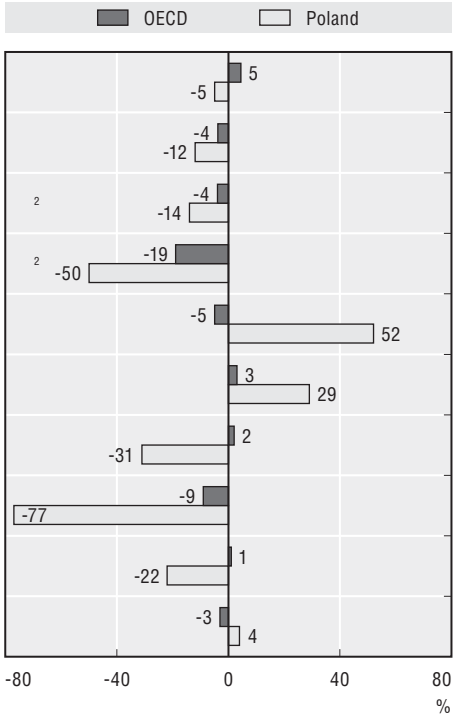
Tax exemptions on fossil fuel used by farmers provide a disincentive to improve energy efficiency, and help further reduce greenhouse gas emissions, especially as agricultural GHG emissions and direct on-farm energy use have been increasing. Renewable energy production based on agricultural biomass, however, is being expanded. Although the current intensity of pesticide and fertiliser use is low, but recently on a rising trend, the reduced value added tax on these inputs does not encourage more efficient use, hence, lowering potential environmental pressure [5].

Agriculture supports a rich and abundant biodiversity [51, 53]. A major concern for biodiversity, however, is the abandonment of agricultural land to plant overgrowth, especially where this involves semi-natural grasslands. In some western parts of Poland the intensification of farming (*e.g.* higher stocking rates, and greater use of fertilisers and pesticides) is also increasing the pressure on biodiversity. The introduction of agri-environmental measures to protect biodiversity will be important, as Poland is host to major remaining populations of many of Europeans endangered farmland bird species [3, 53], while the Carpathians (of which a part falls within Polish territory and is a UNESCO Biosphere Reserve) are an important area of farmed mountainous semi-natural grasslands and cultural landscapes.

Projections suggest that agricultural production is likely to remain stable up to 2015, but the consequences of these projections for the environment are unclear. This is because the projections expect that while dairy and beef cattle production may contract, crop (*e.g.* cereals and sugar beet), pig and poultry production could expand [29, 40]. However, not all projections of Polish agriculture show consistent results when compared with each other. Moreover, the agricultural sector is undergoing structural changes which have environmental implications. A key aspect to structural change in agriculture, which may impact on agri-environmental performance, is the extent to which small semi-subsistence farms can escape the vicious circle of low technical efficiency and technological and educational limitations [15]. As much as 40% of those engaged in agriculture have only elementary education compared to around 10% in industry [16]. Improvements in human capital are clearly crucial to the future of Polish farming and in raising agri-environmental performance, both by improving the efficiency of those remaining in farming and also increasing opportunities for others to leave the sector and seek other employment [16].

Figure 3.22.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

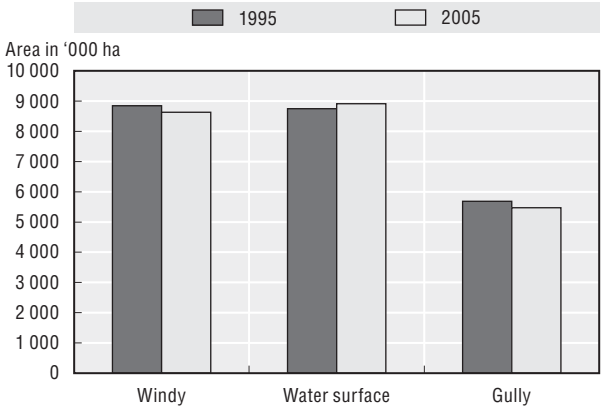
Variable	Unit		Poland	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	95	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–2 221	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	48	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	3	10
Agricultural pesticide use	tonnes	1990-92 to 2001-03	+3 375	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+1 009	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–475	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	0.9	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–90	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	+985	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

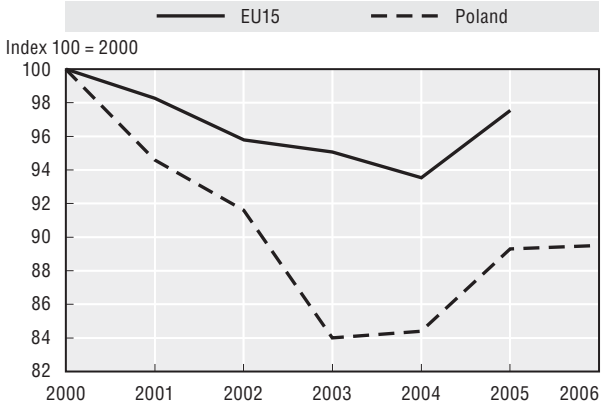
Figure 3.22.3. **Agriculture and forest land at risk to erosion**



Source: Central Statistical Office in Poland.

Figure 3.22.4. **Index of population trends of farmland birds**

2000 to 2006



Source: State Environmental Monitoring Scheme in Poland.

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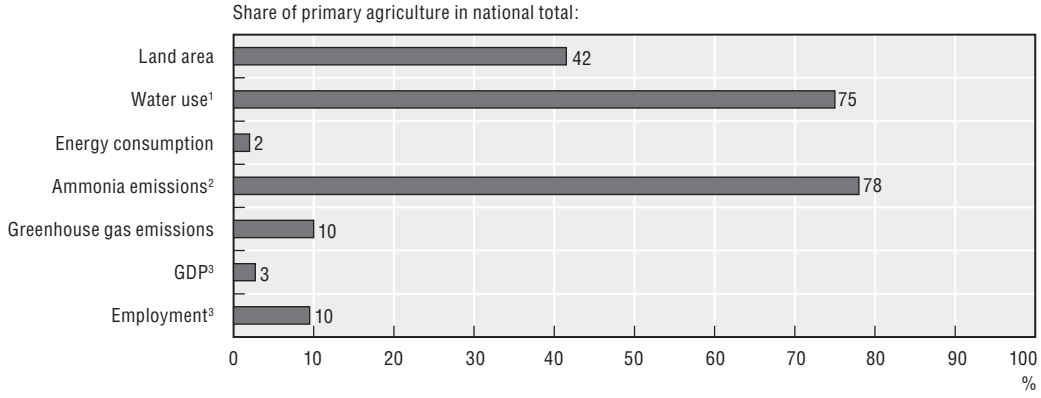
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3.23. PORTUGAL

Figure 3.23.1. **National agri-environmental and economic profile, 2002-04: Portugal**



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1. Data refer to the year 2001.
2. Data refer to the period 2001-03.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.23.1. Agricultural sector trends and policy context

Agriculture's contribution to the economy remains important but is declining. Farming's contribution to GDP and employment has halved since 1990, reaching 2.7% of GDP and 9.5% of total employment in 2004, and its share of total export value was around 6% during 2002-04 [1] (Figure 3.23.1). In terms of natural resources farming accounts for over 40% of total land use and 75% of total water use [1, 2].

Agriculture has undergone significant structural change with environmental implications. Overall farm production volume remained near stable between 1990-92 and 2002-04 while the area farmed decreased by 5%, employment in agriculture declined by 53% and the number of farms decreased by 40%. This has led to the substitution of labour by capital and purchased inputs over the period since 1990, with mixed pressures on the environment in view of the diversity of production systems and farm size across the country. Some purchased farm input use increased, including inorganic nitrogen fertilisers (20%), pesticides (26%), and water use (21%), although there was less use of inorganic phosphorus fertilisers (–23%) and on-farm direct energy consumption (–23%) (Figure 3.23.2). Underlying these changes has been a major shift from crop to livestock production, with the volume of livestock production rising by 15% compared to a reduction of almost 5% in crop production between 1990-92 and 2002-04, although for some crops output rose, notably for maize, sugar beet, olives, and horticultural crops. During the same period the area of pasture rose by over 60% while the arable and permanent crop area declined by almost 25%, such that

pasture now accounts for nearly 40% of total farmland. Nevertheless, crop products still account for more than 60% of the total value of agricultural output in 2004, of which horticultural products, olive oil and wine contributed over 40% [1].

Farming is mainly supported under the Common Agricultural Policy (CAP) with support also provided through national expenditure within the CAP framework. Support to EU farmers has on average declined from 41% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate – PSE) compared to the 31% OECD average. Nearly 70% of EU support to farmers was still output and input linked in 2002-04 (compared to over 90% in the mid-1980s), the forms of support that most encourage production [3]. In 2003, national budgetary expenditures to support agriculture were estimated at EUR 380 (USD 430) million, and the EU funded around 75% of the total support to the sector [3, 4].

Agri-environmental measures have been strengthened since their introduction in 1994. Expenditure on agri-environmental measures rose by 97% from 1996 to 2003, accounting for around 7% of total agricultural budgetary expenditure in 2003. Emphasis is on: reducing soil erosion and agricultural pollution; maintaining extensive farming systems to support biodiversity objectives; managing natural resources (especially soil and water) and cultural landscapes; as well as preserving animal genetic resources for agriculture [4]. Schemes addressing pollution reduction and soil protection are applied nationally, while other schemes are regional and apply mainly to specific farming systems [5]. About 40% of total agri-environmental budgetary expenditure is used for: the maintenance of mixed farming (in the Northern and Central regions); low-intensity olive production; extensive grazing systems (semi-natural grasslands) with payments provided per hectare of EUR 30-260 (USD 38-325) depending on the farming system and area; and the protection of threatened local breeds including payments of EUR 84-139 (USD 105-174) per livestock unit depending on the number of animals [4].

Measures addressing the reduction of farm pollution comprise restrictions on the use of farm chemicals and encouraging greater uptake of integrated environmental farm management practices, including, integrated pest management, and farmer training and demonstration projects. This includes, for example, improving livestock manure storage facilities with 35-55% of investment costs covered and payments differentiated by commodity and farm size of EUR 39-500 (USD 49-625) per hectare, and EUR 70-688 (USD 87-860) per hectare for the adoption of organic farming. There are compulsory pollution discharge limits under the EU *Nitrates Directive* for farms in designated vulnerable areas. Payments to farmers are now conditional on respecting the EU *Nitrates Directive* with improved fertiliser management practices. The use of agricultural conservation practices for the protection of soil against erosion is encouraged, such as direct seeding and minimum tillage, with payments of EUR 8-182 (USD 10-227) depending on the practice and area [4].

National and regional environmental policies have implications for agriculture. As part of the national strategy to prevent desertification, reduce soil erosion and improve water retention, payments totalling nearly EUR 50 (USD 63) million annually are currently provided to farmers (75%) and regional authorities (25%) for afforestation of marginal farmland. These payments cover 50-100% of afforestation costs, compensation costs for loss of income, and forest maintenance costs [6]. National policies seek to manage cultural landscape features [7], with specific farm payments made available for cultural landscape conservation [4]. For example payments for farmed landscapes such as the "Douro" terraced vineyards, EUR 75-374 (USD 94-468) per hectare, and the grazed "Montado" (Holm oak forests) system, EUR 19-94

(USD 24-118) per hectare. In total 17% of farmland was included under the *National Network of Protected Areas* and EU *Natura 2000* sites in 1995-2000 [1, 4], as national conservation of wildlife, especially birds, relies on the maintenance of specific farming production systems that provide the main habitat for those species, such as extensive cereals, "montados", traditional farming and permanent pasture land, such as "lameiros". The conversion of these farming systems to other uses requires special authorisation [8]. Farmers are paid to maintain these farming systems in protected areas, designated mainly under the EU *Habitat* and *Birds Directives*, with payments ranging from EUR 25-900 (USD 31-1 125) per hectare.

Farmers benefit from the reduction in input costs with implications for the environment. Water policies since 1994 require that all ***water use*** (surface and groundwater) is licensed and subjected to a charge based on the quantity used given the region's relative scarcity of water and to cover its opportunity cost, but providing an exemption until 2009 for irrigation [9]. The collection of water charges, however, has never come into force because of difficulties in registering water users. Nearly 80% of the irrigated infrastructure is under private ownership and the remainder provided nationally or by projects collectively built and managed by municipalities and farmers' associations. Under private irrigation projects, farmers can receive a 55% refund of their investment costs. For public irrigation projects beneficiary farmers are not charged for any part of the capital expenditure on the main and secondary distribution network, although infrastructure investment costs at the farm level are under the farmers' responsibility, but with a general refund of 55%. For these public schemes, charges are intended to cover a share of the maintenance and distribution costs. The level of cost recovery is evaluated at 23% for total costs and 114% for maintenance and distribution costs [10]. A tax concession on ***diesel fuel*** is provided to farmers for tractors and farm machinery, equivalent to EUR 77 (USD 96) million annually for 2004 and 2005 of tax revenue forgone [4, 9]. Following the 2003 EU Directive on increasing the use of ***biofuels*** in the transport sector, the use of biofuels (ethanol and) has been exempt from excise taxes of EUR 280 (USD 350) per 1 000 litres since the end of 2006 [9].

International and regional environmental agreements are also important for agriculture. They include those seeking to: curb nutrient emissions into the North Sea and Atlantic (*OSPAR Convention*), although Portugal is not subject to the 50% reduction target for agricultural nutrient under the Convention [4]; lowering ammonia emissions (*Gothenburg Protocol*), methyl bromide use (*Montreal Protocol*) and greenhouse gas emissions (UN Convention on Climate Change); and addressing desertification and soil erosion concerns (*UN Convention to Combat Desertification*) [11]. The improvement of carbon sequestration by agricultural soils, together with forest, as well as emission reduction from intensive livestock production, are important agricultural measures to fulfil the national commitments under the *Kyoto Protocol*. Portugal has a number of environmental co-operation agreements with Spain, notably concerning water resources, as nearly half of Portugal's renewable freshwater resources originate in Spain [4]. The *Convention on the Co-operation for the Protection and Sustainable Use of Waters of Portugal and Spain River Basins*, which entered into force in 2000, covers water quality and resource use, and defines minimum flows for transboundary river basins [4].

3.23.2. Environmental performance of agriculture

The main agri-environmental issues are soil erosion, water quality and use, and biodiversity conservation. Other important agri-environmental issues include agricultural ammonia and greenhouse gas emissions and conservation of cultural agricultural

landscapes. There are a wide variety of agri-ecosystems and landscapes. These range from Mediterranean in the south with hot and dry summers and irregular rainfall during and across years [13], to oceanic climate in the north with a cooler climate tempered by the Gulf Stream but also with a Mediterranean rainfall regime characterised by a dry five months season in the summer [4].

Soil erosion remains a major concern. Around 70% of the total land area is estimated at high risk of erosion, a further 24% at medium risk and 5% at low risk [4, 11]. There is no national soil quality monitoring network, but a number of studies reveal that soil erosion from water is widespread on farmland, especially in the south, where soil erosion research has been undertaken over many decades. However, soil erosion from wind is not a concern [4, 11, 12]. Soil degradation has been aggravated by a combination of unfavourable natural conditions, including a high proportion of steeply sloping farmland, heavy rainfall in autumn and winter when land cover is reduced, thin topsoil, and the semi-arid climate in the south. Soil erosion has also been attributed to: poor farm management depending on the region; cereal growing on unsuitable soils; and overgrazing and forest fires, especially in mountainous areas [11]. In the steeper regions of the north-west the abandonment and collapse of many small irrigated terraces has also increased soil erosion rates [11]. Loss of soil productivity has occurred in the eroded areas as well as sedimentary deposition downstream, with erosion triggering potentially irreversible degradation and desertification [4, 11, 12].

Farming is exerting significant pressure on the quality of water bodies [2, 4, 9, 12]. There are increasing concerns with agricultural pollution from nitrates and pesticides, both run-off into rivers and lakes, and leaching into groundwater, especially shallow aquifers [14, 15, 16]. In the absence of systematic monitoring of pollution in predominantly agricultural water catchments data on agricultural pollution of water bodies is patchy, except for nitrates. There is also some evidence of growing salinity levels in groundwater resulting from irrigation return flows [15, 17].

The agricultural nitrogen surplus rose by 7% between 1990-92 and 2002-04, while the phosphate surplus was stable. But the nitrogen (N) surplus quantity per hectare of agricultural land was almost half (47 kg N/ha) the EU15 averages, while phosphorus (P) surplus per hectare of agricultural land (15 kg P/ha) was above the OECD and EU15 averages in 2002-04 (Figure 3.23.2). There was some improvement in nutrient use efficiency (the ratio of N/P output to N/P input), but P use efficiency was well below the OECD average in 2002-04. The rise in nitrogen surplus is mainly due to higher inorganic fertiliser use and livestock numbers (*i.e.* more manure), especially poultry and pigs, despite the rise in nitrogen uptake with the expansion in pasture area. The stability in phosphorus surpluses resulted from the fall in phosphorus inorganic fertiliser use balanced by the rise in livestock numbers and greater nutrient uptake from higher pasture production.

Agricultural nitrate pollution of groundwater bodies is high in some areas, but the situation is improving. Almost 20% of the monitoring sites in farming areas reported nitrates in groundwater above the drinking water standard (1995-2005) [18], but were even higher in some regions, such as Alentejo [15]. Intensive crop farming on irrigated land and intensive poultry and pig farming are the main causes of nutrient pollution in certain areas [4, 12]. In agricultural nitrate vulnerable areas, over 50% of groundwater monitoring stations were above drinking water standards (50 mg/l) during 1997-99, declining to 37% by 2000-03. Almost 70% of monitoring stations measured a decrease of over 50% of nitrates from agricultural sources in vulnerable areas into groundwater between 1997 and 2003 [1].

The use of pesticides rose by 26% over the period 1996-98 to 2001-03, although around three-quarters of pesticide use is in the form of low-toxicity fungicides, mainly sulphur to control mildew in vineyards (Figure 3.23.2) [4]. Portugal has experienced a high rate of growth in pesticides (active ingredients) over the past decade, mainly for use on irrigated crops (*e.g.* rice, maize, horticultural crops) and vineyards [19]. Monitored pesticides have been detected in surface and ground water in the few agricultural areas where monitoring took place and in some cases are substantially above the EU maximum concentration value for pesticides in drinking water of 0.1 μg/l [14, 19]. Over the period 1983 to 1999 certain insecticide and herbicide products were detected in surface water at between 0.18 μg/l and 56 μg/l [19]. This is of particular concern in groundwater as the country draws over 50% of its drinking water supplies from this source [19]. Nevertheless, monitoring of water for human consumption indicates no problems in terms of harmful pesticide concentrations [20]. Farmers are adopting integrated pesticide management (IPM) practices to lessen the potential pressure of pesticides on the environment, with an increase in the area of IPM as a share of total arable and permanent crop land from less than 1% in 1995 to over 5% by 2002 [18]. In addition, the area under organic farming also rose over the past 15 years to nearly 6% of total farmland by 2005 compared to an EU15 average of nearly 4% (2002-04) [1, 21].

The use of water by agriculture for irrigation grew by over 20% from 1991 to 2001, although data availability is limited. Increasing agricultural water use is in part due to the 3% expansion in the area irrigated between 1990-92 and 2001-03, with 17% of the total agricultural area under irrigation by 2001-03. Irrigation water application rates (litres per hectare of irrigated land) also rose 18% between 1991 and 2001, compared to a decrease of 9% for the OECD on average (Figure 3.23.2). The increasing intensity of irrigation water use is of concern since irrigation is shifting from the North, which is best endowed with water, to the South, which is least so [4, 12]. Research suggests farming is over exploiting aquifers and extracting water beyond rates of replenishment in the Algarve, although since the 1980s abstraction from aquifers has to be licensed [4, 16, 17]. About 10% of public and private irrigation infrastructure was rehabilitated between 1996 and 2000 at a cost of EUR 35 (USD 44) million [4]. The Alqueva water development project in the Guadiana basin (to be completed in 2024) has a major irrigation component, which is expected to cover 110 000 ha, leading to the expansion in irrigated land area of around 15% above the level of 2001-03, although some of it is already irrigated with less efficient systems [4, 22]. EU structural funds will cover a large part of the EUR 1.88 (USD 2.35) billion investment for this project [4].

Air pollution trends linked to farming have been mixed. Agricultural ***ammonia emissions*** rose by 13% between 1990-92 and 2001-03, mainly as a result of the increase in livestock numbers and nitrogen fertiliser use (Figure 3.23.2). Farming accounted for nearly 80% of total ammonia emissions in 2001-03. Despite the rise in total ammonia emissions to around 65 000 tonnes by 2001-03, this remains well below the 2010 target of 108 000 required under the *Gothenburg Protocol*. For ***methyl bromide*** use (an ozone depleting substance) Portugal, along with other EU15 countries, reduced its use over the 1990s as agreed by the phase-out schedule under the *Montreal Protocol*, which sought to eliminate all use by 2005. But in 2005 a "*Critical Use Exemption*" (CUE) was agreed up to 30 tonnes for Portugal (ozone depleting potential), or about 1% of the EU15's CUEs, which under the Protocol allows farmers additional time to find substitutes.

Agricultural greenhouse gas (GHG) emissions increased by 6% between 1990-92 and 2002-04, while there was a 36% rise in total GHG emissions for the Portuguese economy as a whole (Figure 3.23.2). Under the EU *Burden Sharing Agreement* for the *Kyoto*

Protocol Portugal can increase total GHG emissions up to 27% by 2008-12 from the 1990 base year [23]. The share of farming in national GHG emissions was 10% in 2002-04 and the main sources and growth of agricultural GHGs are methane from livestock and nitrous oxide from fertilisers and manure applied on soils [23]. Agricultural GHGs emissions are projected to further increase up to 2008-12, mainly because of higher livestock numbers and fertiliser use, although the rate of emission increase is expected to be reduced due to improved manure management practices [23]. In addition, agricultural emissions might be further reduced with an expansion in ***carbon sequestration by agricultural soils and forests*** being promoted through the incentives for afforestation of marginal agricultural land, minimum tillage practices and improved pasture systems [24].

The drop in direct on-farm energy consumption of 23% compared to a rise of 50% across the economy, over the period 1990-92 to 2002-04, has helped lower GHG emissions, with farming accounting for about 2% of total energy consumption (Figure 3.23.2). But the projected growth in the farm sector could see energy consumption rise, unless energy efficiency gains are realised [25]. Up to 2006 farming produced no feedstock for ***renewable energy production***, although tax incentives were introduced at the end of 2006 to encourage its development [25].

The intensification and structural changes in agriculture has led to greater pressure on biodiversity, but there are signs of the pressure easing and the area of low intensity production systems remains important [4]. However, disentangling the impacts of farming activities on biodiversity is difficult because of the complex relationship between agricultural production systems and biodiversity conservation. This is mainly due to a lack of data, but also because of a combination of: the continued process of intensification in fertile areas; flooding habitat for irrigation; conversion of land for urban use; in marginal farming areas the afforestation or abandonment of semi-natural farmed habitats; and an overall increase of pollutants into the environment, especially nitrates, pesticides and ammonia emissions, raising pressure on terrestrial and aquatic ecosystems [4].

Agricultural genetic resources for crop varieties used in production have increased in diversity, over the period 1990 to 2002, except for cereal and forage varieties. There are also *in situ* conservation programmes mainly for maize and beans, and an extensive *ex situ* collection of crop germplasm [18]. For livestock there was no change in numbers of livestock breeds used in marketed production between 1990 and 2002. Payments are provided to farmers to help with *in situ* conservation of local threatened breeds, and a programme is underway aimed at establishing *ex situ* collections of their genetic material (Figure 3.23.3) [18].

Adverse changes in the quantity and quality of farmed habitats are a risk for biodiversity conservation. Despite the absence of regular monitoring of trends in flora and fauna linked to agriculture, changes in the quantity (area) and quality of farmed habitats provide indirect evidence of likely impacts of farming on wild species (Figure 3.23.4). The overall 5% reduction in farmland between 1990-92 and 2002-04 mainly involved the conversion of farmland to roads, urban development and forestry, although the net impact on biodiversity through conversion to forests is unclear. The area under fallow nearly halved and there was a decrease in ***semi-natural farmed habitats***, including "traditional" orchards (4%), and uncultivated farmland (17%) between 1990 and 2000. But over the same period the area of some semi-natural habitats almost doubled, including extensive pasture and wooded pasture, improving the conditions to support wild species [18]. Assessing the overall trends of agriculture's impact on habitats and wild species is hampered, however, by insufficient data.

The change and loss of semi-natural farmed habitats has been detrimental to bird populations [26]. This is of particular importance as the Iberian peninsula supports a major share of some globally threatened bird species, notably the Little Bustard (*Tetrax tetrax*) and Great Bustard (*Otis parda*) [27, 28]. The intensification of extensive cereal farming systems has been especially damaging to populations of Bustards, while increases in pasture and irrigated crops are unsuitable habitats for these bird species [27, 28]. Moreover, the importance of farming practices on bird populations is also revealed by the BirdLife International Important Bird Areas (IBAs) indicator, defined as prime bird habitat. The indicator shows that around 50% of the most significant threat to Portuguese IBAs originates from farming, including not only intensification of production but also the loss of semi-natural farmed habitat to other uses, while the construction of irrigation projects threatens nearly 40% of IBAs [29]. But there is evidence that agri-environmental measures have helped increase bird diversity and abundance, such as the restoration of low intensity farming practices in the *Special Protection Area* of the Castro Verde [4]. Other threatened species, such as the Cabrera Vole (*Microtus cabrerae*), require the maintenance of uncultivated agricultural habitats (*e.g.* field margins, ditches, fence lines, etc.) for their survival [30]. While some of these habitat features have been changed to other uses, overall the area of uncultivated farm habitats has increased.

Certain semi-natural farming systems are also important as cultural landscapes, as well as providing biodiversity. The *Montado* is an agro-forestry pastoral system in southern Portugal, characterised by a combination of an open tree cover of Cork Oak (*Quercus suber*) and Holm Oak (*Quercus rotundifolia*), which support extensive livestock grazing [4, 31, 32]. The *Montado* closely resembles the Spanish *Dehesa* farming system [31, 32]. Similarly the *Lameiros* provides hillside permanent pasture farming, in the north, irrigated by a system of centuries old terraces [4]. Both the intensification of these farming systems and also in some regions their abandonment to shrub or forest has been to their detriment [31]. Since the mid-1990s the conservation of these farming systems has been encouraged through both training farmers to improve management practices and providing payments to farmers adopting conservation practices that go beyond good agricultural practice (Figure 3.23.4) [4].

3.23.3. Overall agri-environmental performance

Overall the pressure on the environment from farming has risen since 1990 [33]. The growing intensity of farming is evident with the increase in use of nitrogen fertilisers, pesticides, and water, while the area farmed declined. In addition, there was greater pressure on ecosystems, terrestrial and aquatic, with an increase in nitrogen surpluses and higher emissions of ammonia and greenhouse gases. Soil erosion remains a major concern and irrigation water application rates rose in comparison to a downward trend for most other OECD countries where irrigation is important. There are also concerns over the loss to other uses and abandonment of semi-natural agricultural habitats, to the detriment of the biodiversity and cultural landscape benefits associated with these habitats.

There is a need to strengthen agri-environmental monitoring and evaluation systems. This would provide information for policy makers to help monitor agri-environmental policy measures and evaluate their environmental effectiveness [4, 12]. The extent of pesticide monitoring is limited to concentrations in water for human consumption, but researchers consider the coverage of monitoring should be extended [19]. The pollution and extraction of groundwater by agriculture also requires more comprehensive monitoring [15]. Despite the

importance of soil erosion there is no national monitoring network, while the impacts of agriculture on biodiversity and cultural landscape features are not regularly measured.

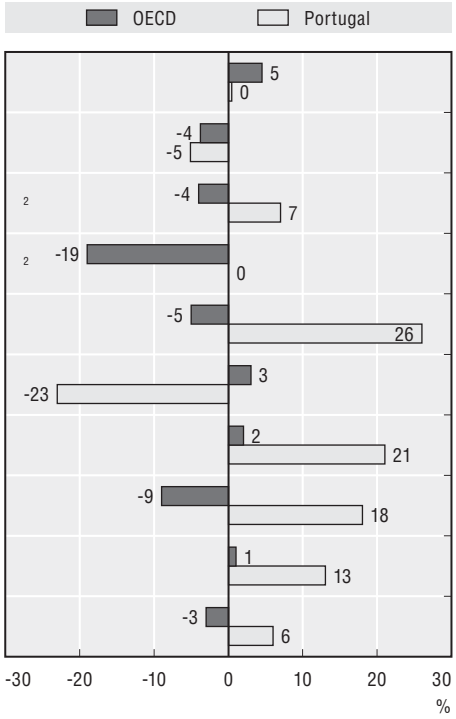
Greater policy attention is being paid to help improve environmental performance in agriculture, with some signs that environmental improvement is emerging. The area covered by agri-environmental measures rose to nearly 25% of farmland by 2000, mostly concentrated in Northern (52%) and Central (37%) regions. This is above the 15% target set for 2000 under the EU's *Fifth Environmental Action Programme*. Since 2000 greater policy attention has been paid to addressing soil erosion problems on farmland, including promoting soil conservation practices (*e.g.* extensive forage systems and low tillage) and agro-forestry [4, 11]. These measures will also address rising GHG emissions by promoting sequestration of carbon in farmed soils [23]. Agri-environmental measures have encouraged the adoption of integrated pest management and organic farming, while some improvement to biodiversity and cultural landscape conservation has been stimulated through payments to maintain semi-natural extensive farmed habitats and landscapes. The 2005 *Water Law*, which translates the EU *Water Framework Directive* of 2000 into national legislation, provides the potential to limit water pollution and excessive water abstraction by agriculture, providing the framework for the implementation of the polluter-pays-principle and cost recovery for water in projects, such as the Alqueva project [4, 9]. With regard to water quantity, the *National Programme for the Efficient Use of Water* provides guidance and sets targets to improve the management of this natural resource [34]. The implementation of the measures dealing with GHGs will help to improve water quality and soil protection [24].

Subsidised input costs do not provide incentives to conserve resources [4]. Farmers have little incentive to conserve water resources given the support provided to water charges and irrigation infrastructure costs, highlighted by the rise in irrigation water application rates (megalitres/hectares irrigated) compared to a reduction for the OECD on average. While households and industries pay a share of the cost of public treatment and distribution of water, farmers pay a smaller share of those costs [12]. The Alqueva water development project in the Guadiana basin has raised a debate in Portugal about how the capital, maintenance and operation costs of the project should be shared among different water users [4]. ***Fuel tax concessions*** for farmers undermine more efficient use of energy and may lead to higher GHG emissions, of particular significance as agricultural GHGs have been increasing, although direct on-farm consumption has been reduced.

A number of important agri-environmental issues still need attention [33]. The major problem of ***soil erosion*** needs to be addressed by greater uptake of soil conservation practices, although the recent EU *Soil Strategy and Framework Directive* could help to improve soil conservation [12]. Despite the progress made since 2000 regarding ***nitrate pollution***, with 6% of farmland designated as nitrate vulnerable zones (NVZs) under the EU's *Nitrates Directive* in eight different areas, the adoption of the farm practices necessary to improve the pollution situation is still under way. There are concerns with ***pesticide pollution*** of water bodies, especially groundwater as this is a major source of drinking water supplies [14, 19]. The costs of removing farm nutrient and pesticide pollutants from drinking water are passed onto water treatment plants and other water users. Farmers have little incentive to control pollution, although a code of good farming practice has been in place since 1997 to help reduce pollution and failure to observe it makes them liable to financial penalties [12]. ***Biodiversity conservation*** requires greater adoption of environmentally beneficial farm practices and maintenance of specific production systems in protected areas, which may depend on the government's capacity to promote rural development strategies in the future [33].

Figure 3.23.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

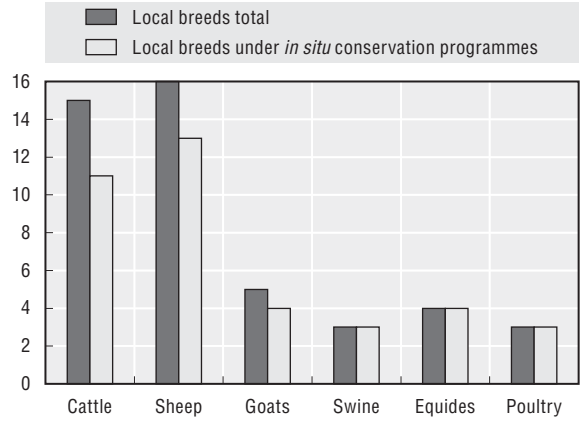
Variable	Unit		Portugal	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	100	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–200	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	47	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	15	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	+3 461	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–135	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+1 078	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	9.5	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	+6	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	+490	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

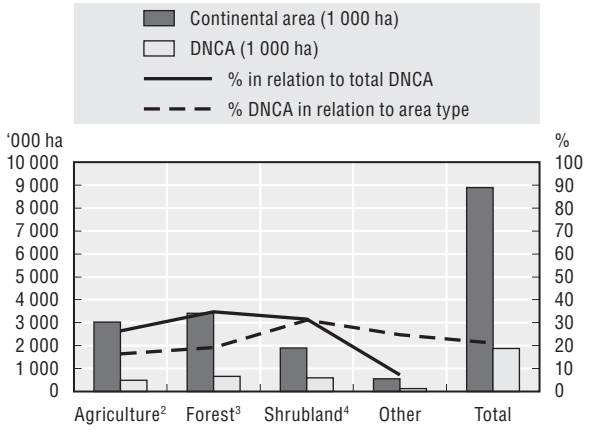
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.23.3. **Numbers of local breeds under *in situ* conservation programmes: 2006**



Source: Gabinete de Planeamento e Políticas, MADRP, 2007.

Figure 3.23.4. **Relation between land use and Designated Nature Conservation Areas (DNCA):[1] 2004**



1. Includes Nature 2000 sites and national network of protected areas.
2. Does not include under cover agricultural areas.
3. Includes under cover agricultural areas.
4. Includes pastures, fallow land and uncultivated areas.

Source: National Forestry Inventory, DGRF 2005/06.

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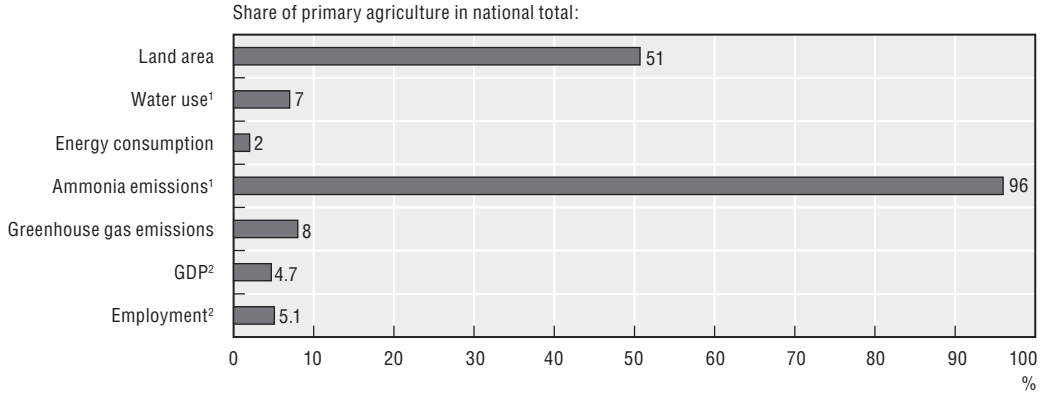
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3.24. SLOVAK REPUBLIC

Figure 3.24.1. **National agri-environmental and economic profile, 2002-04: Slovak Republic**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.24.1. Agricultural sector trends and policy context

The long-term contraction of the agricultural sector continued over the period 1990 to 2004. The share of agriculture in GDP declined steadily from 8% in 1990 to slightly under 5% by 2004, while over the same period farming's share in total employment fell from 12% to 5% [1, 2, 3, 4] (Figure 3.24.1). These changes reflect the reduction of 10% in the volume of agricultural production (1993-95 to 2002-04), among the largest decrease across OECD countries (Figure 3.24.2). While livestock numbers continue to decline, part of a longer term trend since 1990, more recently from 2000 to 2004 arable crop production has recovered and risen slightly, especially for cereals, oilseeds and sugar beet [1].

Transition from a centrally planned to a market economy has impacted significantly on agriculture since the early 1990s. Together with the division of Czechoslovakia into the Slovak and Czech Republic's in January 1993, this has led to major changes in political and social institutions and economic conditions, had implications for land use, and resulted in extensive changes in farm ownership patterns, productivity and competitiveness [3, 5, 6, 7, 8, 9, 10, 11, 12, 13]. The sharp fall in the volume of farm production during the early 1990s was induced by a major reduction in support (see below), a drop in farm investment, and rising farm debt levels. The use of purchased farm inputs (fertilisers, pesticides, energy and water) decreased sharply in the early 1990s but stabilised and even began to rise slightly from the late 1990s, although by 2005 still remained well below their peak of the late 1980s (Figure 3.24.2) [1, 3, 5].

Private family farms saw their share of the area farmed rise from zero before 1992 to over 12% by 2003, but the share of farmland managed (but not all owned) by large corporate farms (privatised successors of former state and co-operative farms) was over 85% in 2003 [1, 6]. The average size of corporate farms at about 1 600 hectares in 2003 is well above the EU average [1]. Agricultural productivity (as measured by total factor productivity) rose by around 2% annually between 1992 to 2002, mainly due to the sharp decline in farm employment [14], with agricultural labour productivity (real GDP per employee) higher in agriculture than in many other sectors of the economy during this time [1, 15].

Farming is now supported under the Common Agricultural Policy (CAP), with support also provided through national expenditure within the CAP framework. Support to agriculture has fluctuated considerably over the past 20 years. Due to the implementation of economic reforms, support declined from almost 60% of farm receipts in the mid-1980s to a low of 10% in 1996 (as measured by the OECD Producer Support Estimate – PSE), but then gradually rose (except in 2001 when it dipped to 16%) to 21% by 2003, as policies were geared toward EU membership in 2004 [6, 16, 17]. The EU15 PSE was 34% in 2002-04 compared to the 31% OECD average [8, 15]. Nearly 70% of EU15 support to farmers was output and input linked in 2002-04, the forms of support that most encourage production [18]. Total annual budgetary support to Slovak agriculture was SKK 5.6 (EUR 149 million) billion in 2005, of which about 60% was nationally financed, the remainder coming from EU funding [18]. Agri-environmental measures in the Slovak Republic accounted for about 10% of total budgetary support in 2002 and 2003 [19].

Agri-environmental and environmental policy has had to address some key problems. Firstly, policy had to respond to the environmental problems that are a part of the legacy of central planning; and secondly, policy changes have been required for EU accession and membership (see below). In the early years of transition, agri-environmental policy was not a priority, and the government lacked resources to invest in environmental protection [20]. Indirectly, however, through the removal of government support for purchased farm inputs (*e.g.* fertilisers by 1999, pesticides, but not fuel or irrigation infrastructure) and other production related support had the effect of lowering agricultural production intensity and pressure on the environment. Agri-environmental policies, however, were first introduced in 1997 to encourage sustainable farming practices and environmental protection, including organic farming in 1998 [2, 6]. Between 1992 to 2004 to protect the most fertile agricultural land from conversion to non-agricultural uses it was evaluated and approved before conversion, with a tax imposed on the land removed from agricultural use, but from 2004 the tax was removed [3].

EU accession and membership from 2004 has also brought policy change. The EU provided pre-accession funds for agriculture up to 2006 (including for environmental purposes) through three programmes: *SAPARD*, the most important for agriculture in terms of funding the establishment of institutions and systems of policy implementation; *PHARE*, covering institutional building; and *ISPA*, to assist infrastructure development, including environmental protection [16, 20, 21]. The EU accession period since 2004 has required the adoption of EU agri-environmental and environmental policies, and harmonisation of technical standards [8, 20]. Policies under the CAP are being phased in up to 2013, when CAP support will reach 100% of the EU15 level.

The joint national-EU funded Rural Development Plan (RDP) provided the main agri-environmental schemes for 2004 to 2006, including principally area payments per hectare of arable land, permanent cropland (*e.g.* orchards, vineyards) and permanent

grassland (fixed rates defined for each category) conditional on adoption of environmental farm management practices; support for conversion of arable land to permanent pasture; and payments for organic farming [22]. Since 2005 payments are provided for conversion to organic farming (varying from SKK 4 000-10 000 per hectare, EUR 104-259) and post conversion support (varying from SKK 2 000-5 000 per hectare, EUR 52-130) [1, 7, 23]. There are also a number of national agri-environmental programmes that provide support for conservation of agricultural genetic resources (crops and livestock) [16, 19, 22, 24]. To comply with the *EU Nitrates Directive*, the 2002 *Water Act* defines the practices (*e.g.* manure storage, application) required of farmers, and in 2004 about 60% of agricultural land was designated as *Nitrate Vulnerable Zones* [3, 25, 26, 27]. It was estimated in 2001 that the cost to comply with the Directive by 2008 would total SKK 23 billion (EUR 545 million) [26].

Agriculture is affected by national environmental and taxation policies. Support is provided for some farm inputs, important from an environmental perspective, including for fuel and water [3, 19]. Farm fuel use has been supported through a tax exemption since 1996, and after peaking at around SKK 1 600 (EUR 36) million in 2001 declined to SKK 930 (EUR 24) million by 2005 of annual budget revenue forgone [18, 28]. Since 2000 ammonia emissions are taxed at SKK 2 000 (EUR 48) per ton per year [4]. Support is also provided to reduce costs of irrigation water supply by up to 50% from surface water (including energy costs for pumping water), the main source of irrigation water, but farmers pay abstraction charges for groundwater [3, 18]. Support was also provided for irrigation infrastructure operational and maintenance costs, amounting to SKK 30 (EUR 0.8) million in 2006 [18, 29], but since 2007 national support for irrigation water supply has been removed.

The Slovak Republic is a signatory to a number of international environmental agreements, some with implications for agriculture including limiting emissions of: ammonia (*Gothenburg Protocol*), methyl bromide (*Montreal Protocol*) and greenhouse gases (GHGs) (*Kyoto Protocol*). As part of the national effort to reduce GHG emissions biofuels are exempt from excise taxes [3, 30]. In terms of its commitments under the *Convention of Biological Diversity*, the *National Biodiversity Strategy*, along with a range of other measures, promotes the conservation and use of agricultural genetic resources through a *National Action Programme* as well as the protection of mountain biodiversity and agricultural landscapes [3]. Slovakia also has a number of bilateral and regional environmental co-operation agreements with neighbouring countries, in particular, of importance to agriculture is the *Carpathian Convention* (2006) covering the conservation of semi-natural farmed grassland in the area of the Carpathian mountains partly included within the country's borders [3, 31], and the *European Landscape Convention* (2005) aiming to promote European landscape protection, management and planning, and to organise European co-operation on landscape issues [32].

3.24.2. Environmental performance of agriculture

Environmental concerns related to agriculture have changed significantly since 1990. With the reduction in farm production and input support, and shift to a market economy, farming moved from an intensive production orientated system to the adoption of more extensive farming methods, linked particularly to the large decrease in use of purchased farm inputs. In the pre-transition period intensification of production led to excessive use of fertilisers, over stocking of livestock on fragile land, and damage to biodiversity [3, 7]. Over the 1990s some of these environmental problems persisted due to the legacy of

decades of damaging farming practices, notably concerning soil erosion [2, 7]. While the pressure on water quality and biodiversity has eased with more extensive farming practices, agricultural water pollution continues and land use change and cessation of farming has led to damage to biodiversity in some areas [2, 3, 7].

Soil erosion is a major and widespread environmental problem, partly because of the predominance of mountainous land, but also due to the high share of arable land in total farmland at over 60% [1, 2, 4, 7, 31, 33, 34]. Data (based on a model) for the period 1990 to 2004 indicate that approximately 47% of farmland is potentially (*i.e.* the worst case scenario) affected by a medium to extreme risk of ***water erosion*** (greater than 10t/ha/year). While the share of farmland at moderate to severe risk of water erosion remained stable over the period 1990-92 to 2002-04, the actual area affected declined over this period by around 8 000 hectares. Of the farmland at risk to moderate to severe water erosion, nearly two thirds is subject to extreme water erosion risk (greater than 33t/ha/year), especially in the farmed areas of the Carpathian mountains [4, 34, 35, 36]. The area at moderate to severe risk of ***wind erosion***, is considerably lower at 6% of agricultural land (2003-04), mainly in some parts of the Danube and West Slovakian (Záhorská) Lowlands [4, 34, 36]. Research suggests that highly eroded soils ***on farm*** has reduced fertility considerably compared to unaffected farmed soils, lowering cereal and oilseed crop yields by between 35% to 76% [34]. ***Off-farm damage*** has also been significant with flows of soil sediment impairing reservoir capacity and aquatic ecosystems in rivers [34].

The quality of agricultural soils is also affected by other degradation processes [1, 4]. Farm soil quality is impacted by ***soil compaction***, with about 8% of farmland affected in the early 2000s, and a further 19% share where the process of compaction is progressing due to the greater use of heavy machinery and inappropriate farming practices [1, 4, 7]. ***Soil acidification***, mainly near industrial areas, although agriculture also produces acidifying emissions, affects around 17% of farmland in the early 2000s [1, 7, 12]. The problem of soil acidification has diminished over the 1990s with the decrease in acidifying emissions from industry, lower acidic fertiliser use, and due to the liming of acidic soils [4]. Levels of soil liming, however, are considered to fall well short of requirements [7] and the share of acid soils are likely to gradually increase [37]. ***Waterlogged soils*** is another concern, with over 20% of agricultural land permanently affected by waterlogging mainly because of high groundwater levels and soil structure [4].

There has been some progress in increasing farmer adoption of soil conservation practices since 1990, but adoption rates remain very low. The share of arable land under soil conservation practices (*e.g.* conservation tillage, contour cultivation, crop rotations, winter cover crops) rose from 8% to 12% between 1995-99 and 2000-03 [36]. Moreover, the overall share of arable and permanent crop under vegetative cover over the year is very low (around 9% in 2002), and declining (13% in 1992) compared to many other OECD countries (over 60%) [36]. Investment in soil conservation declined considerably over the 1990s compared to the levels during the centrally planned era [34].

Overall there has been a long term decline in water pollution from agricultural activities, between 1990 and 2004 [19]. This has been closely associated with the sharp decrease in nutrient surpluses, especially as a result of lower fertiliser use and livestock numbers, and the decline in pesticide use over the period [1]. But since the late 1990s there has been a small rise in nitrogen surpluses (but not phosphorus) and pesticide use, with the pollution of surface water and groundwater in some intensively farmed areas remaining stable and in certain cases slightly rising [2].

There have been substantial reductions in agricultural nutrient surpluses (Figure 3.24.2). The reduction in support to fertilisers and crop and livestock products since the early 1990s, largely explains the decrease in nutrient surpluses. The trends in nutrient surpluses, both of nitrogen (N) and phosphorus (P), fluctuated considerably between the late 1980s and 2004. In the late 1980s nitrogen surpluses (expressed as kg N per ha) were at a level comparable to the EU15 average (but the P surplus was much above EU levels), although by the early 1990s nitrogen surpluses were more than halved, and P surpluses decreased from around 30 kgP/ha of farmland in the late 1980s to under 1 kgP/ha by the late 1990s. But from the late 1990s, while there has been a slow increase in N surpluses (but not for P surpluses), they were still well below the levels of the late 1980s. These developments are highlighted by fluctuations in the use of inorganic N fertilisers which fell from (figures in brackets are for P fertilisers) around 220 000 (170 000) tonnes in the late 1980s down to 70 000 (17 000) tonnes in the early/mid 1990s, rising to over 80 000 (18 000) tonnes by 2002-04 [36].

Agricultural pollution of water bodies from nutrients has declined since 1990, but in some regions pollution is a concern, especially Western Slovakia [2, 3, 7]. Overall water pollution levels from agricultural nutrients is well below that for many EU15 countries, and concentrations in water bodies has been stable or declined in some areas [3]. Despite reductions in ***nitrogen*** surpluses, 14% of groundwater monitoring points in agricultural areas exceeded EU standards on nitrate in drinking water (1985-2002), although this applied to only 1% of monitoring points for surface water [36]. A study in 1999 estimated that 47% of agricultural land had only a low to moderate threat of polluting water, 43% posed a medium threat to water quality with nitrates, while the remaining 10% of farmland was a high threat [2]. Eutrophication of some water bodies has been harmful to aquatic ecosystems [3]. ***Phosphorus pollution*** of surface water has been was much higher than for nitrates, with 30% of monitoring points in agricultural areas exceeding EU standards on phosphorus in drinking water (2002) [36].

The agricultural land area under nutrient management plans has declined sharply. The share fell from 75% in 1985-89 down to 5% by 2000-03 [35]. This is now at a level considerably lower than most EU15 countries where the share of farmland under nutrient plans is commonly above 50%. Similarly the numbers of farms conducting a regular soil nutrient test (every 4-5 years) declined over the same respective periods from 90% down to 70% [35]. Moreover, while there has been a slight improvement in nutrient use efficiency (ratio of nutrient N/P inputs to outputs), mainly due to fertiliser consumption, efficiency ratios are below EU15 and OECD averages, substantially so for phosphorus. The declining adoption of nutrient management practices are largely attributed to farmers' lack of capital to invest in manure storage and other manure treatment technologies [25]. Even so, during the 1980s the maintenance of manure storage facilities was poor, and enforcement of nutrient practices weak [26].

Trends in pesticide use have fluctuated greatly during the period 1990 to 2004 (Figure 3.24.2). From a peak of nearly 5 000 tonnes (of active ingredients) in the late 1980s, pesticide use fell sharply to 2 500 in 1992, but has subsequently risen (leaving aside annual fluctuations) to about 3 500 by 2002-04 [1]. The reduction in support to pesticides and crops during the transition period explains much of the decrease in pesticides use, but also to a limited extent the expansion in organic farming. Organic farming grew rapidly over the 1990s, although accounted for less than 3% of farmland in 2002-04, below the EU15 average of nearly 4%, but above the OECD average [23, 39]. Permanent grassland accounted for about 70% of land under organic management, with much of the remainder arable land,

and a small share under horticultural crops [1]. While initially the reduction of pesticide use in the early 1990s lowered pressure on water quality, with growing use since then this has increased pressure in some regions. Overall, less than 1% of groundwater (wells) monitoring points in agricultural areas exceeded EU standards for pesticides between 1985-2002 [36]. Despite the ban on many highly toxic and persistent organochlorine pesticides (*e.g.* DDT), however, research in 2002-03 has shown that in some districts (*e.g.* Michalovce) they were found at levels in children that should be a cause for concern [40].

As agriculture is largely rain-fed use of irrigation is limited, accounting for 6% of the total farmland area in 2001-03, and used mainly for horticultural crops. Farming's share in national water use was 7% in 2001-03, while over the period 1990-92 to 2001-03 agricultural water use declined by over 60%, largely because the area irrigated halved over this period following the privatisation of some irrigation schemes and a lack of investment in irrigation infrastructure (Figure 3.24.2) [3, 4]. With the greater incidence and severity of droughts (in 2000 the severe drought was estimated to have cost agriculture SKK 11 billion-EUR 245 million), agri-environmental schemes are being used to upgrade and improve the current irrigation infrastructure, with the area under irrigation increasing (2004-05) [4, 7, 39]. Most water used for irrigation is drawn from surface water, with farming accounting for 5% of total groundwater use in 2002. High-pressure rain guns are the main water application technology used by farmers [36]. In the past the construction of irrigation systems has led to damage of wetlands and other habitats [7].

The decrease in air-polluting emissions from agriculture has been among the largest reduction across OECD countries since 1990. Total ***ammonia emissions*** fell by 44% between 1990-92 and 2001-03, with agriculture accounting for 96% of these emissions in 2001-03 (Figure 3.24.2) [42]. The drop in emissions has been mainly due to the reduction in livestock numbers and, to a lesser extent, nitrogen fertiliser use, with livestock accounting for over 90% of agricultural ammonia emissions [2, 4, 42]. With total ammonia emissions falling to 31 000 tonnes by 2001-03, the Slovak Republic has already achieved its 2010 emission ceiling target of 39 000 tonnes required under the *Gothenburg Protocol* [40]. Both soil and water acidification have decreased over the past 15 years along with the reduction in agricultural ammonia and other sources of acidifying emissions [42]. For ***methyl bromide*** use (an ozone depleting substance) the Slovak Republic is one of only a few OECD countries to have eliminated its use well ahead of the complete phase-out agreed under the *Montreal Protocol* for 2005.

The decrease in agricultural greenhouse gas (GHG) emissions decreased by 42% from 1990-92 to 2002-04, was the largest reduction across the OECD (Figure 3.24.2). This compares to an overall reduction across the economy of 22%, and a commitment under the *Kyoto Protocol* to reduce total emissions by 8% over 2008-12 compared to 1990 levels [1, 42]. Agriculture's share of total GHGs was 8% by 2002-04. Much of the decrease in agricultural GHGs was due to lower livestock numbers (reducing methane emissions) and reduced fertiliser use (lowering nitrous oxide emissions) (Figure 3.24.3) [40]. Projections suggest that agricultural GHG emissions will stabilise in the period from 2005 to 2010, rising slightly after this period, although by 2020 are expected to be only at about a third of the 1990 level of emissions [43].

Agriculture has contributed to lowering GHG emissions by reducing direct on-farm energy consumption, but also by expanding renewable energy production and carbon sequestration in agricultural soils. On-farm energy consumption fell by over 70% between 1990-92 and 2002-04 (compared to a reduction of 21% for total national energy consumption), among

the largest reduction across OECD countries [42]. This is mainly because of the decrease in producer support leading to lower production, and also higher energy prices. Farming accounted for only 2% of total energy consumption in 2002-04.

Renewable energy production from agricultural biomass feedstocks is expanding, but remains under 3% of total primary energy supply [30, 43]. The main agricultural sources for renewable energy production are: straw used for heating; liquid cow manure to produce biogas, with 24 biogas units in operation in 2004; oilseeds, mainly rapeseed used to produce 15 000 tons of biodiesel in 2004, with installed capacity for biofuel production at 125 000 tons in 2004 [1, 30]. Projections indicate a large increase in biomass (not only from agriculture) and biogas production up to 2010, possibly raising their share in renewable energy production (in energy equivalent) from 3% in 2002 to nearly 7% by 2010 [43]. There is considerable physical capacity to expand the use of agricultural biomass for renewable energy production, especially for heat generation and biogas [1, 30].

Carbon sequestration associated with agriculture has increased since 1990, contributing to a reduction in GHG emissions [43]. The rise in carbon sequestration has been largely due to the conversion of cropland to pasture, and to a lesser extent farmland converted mainly to forestry [43]. Over the period 1990-92 to 2002-04 the area of agricultural land declined by less than 0.5%, reflecting a 5% in the area under crops and permanent crops, but an 8% rise in the area of pasture. Projections suggest that the carbon sink role of agricultural land would continue from 2005 to 2010 and beyond, but remain stable [43].

Evaluating the effects of agriculture on biodiversity over the past 20 years is complex. This is because of the inheritance from the previous centrally planned economy which led to widespread damage to biodiversity, such as species rich meadows, land drainage (*e.g.* loss of wet meadows), and intensive grazing on marginal soils [7, 44]. Over the 1990s, the pressure on biodiversity from farming activities diminished, especially with the reduction in fertiliser and pesticide use and conversion of cropland to pasture [7]. But while the overall farming system has become more extensive, in certain areas the abandonment of semi-natural farmed grassland habitats has emerged as a threat to biodiversity, especially some endangered birds [3, 7, 44].

There are active* in situ *and* ex situ *programmes for agricultural genetic resource conservation [24]. ***Crop varieties*** used in production have in general increased in diversity over the period 1990 to 2002, although for some varieties of oilcrops, pulses, vegetables and forage they have declined [36]. Crop genetic resources are mainly conserved *ex situ* in national gene banks and research centres, but gene banks of native wild plant species have not yet been established [24]. ***Livestock breeds*** used in marketed production have increased in number over the period 1990 to 2002, with a national programme since 1998 covering *in situ* conservation of livestock breeds and an *ex situ* gene bank established in 2000 [24, 36]. Most endangered livestock breeds are now under *in situ* conservation programmes [36].

Overall pressure on wild species using agricultural land as habitat has eased, mainly reflecting the increasing area of pasture and shift towards a more extensive farming system. With only a small decline in total agricultural land between 1990-92 to 2002-04 (a reduction of 11 000 hectares), the key change to agricultural habitats has been the conversion of about 6 000 hectares of cropland to pasture per annum [36, 39]. About a third of specially protected habitats across Slovakia are farmed (Figure 3.24.4), while semi-natural grassland accounted for about 12% of agricultural land in 1998, equal to about a third of all permanent grassland [4, 7, 12, 44, 45].

The two key threats to semi-natural grasslands (which are usually associated with a rich and abundant wildlife that coexists with livestock at low stocking densities), are their switch to more intensive forms of management (*i.e.* higher stocking rates), and second, in some marginal mountain areas their abandonment to overgrowth as they were often sites converted to cropland in the pre-transition period but unsuited to farming [7, 9, 44]. In this context, the ***White Carpathians***, a mountainous region in the north and north-western part of Slovakia, is of significance as it has been recognised as a UNESCO Biosphere Reserve since 1996 with much of the region under pastoral semi-natural grassland. These grasslands are considered to be among the most species rich in Europe with many protected plant species, such as those belonging to the orchid family [31, 45, 46]. But their continued existence is coming under a variety of threats, especially the increase in the area under fallow and the reduction in livestock over the 1990s leading to the abandonment of some areas or in others under grazing below a level necessary to maintain the plant species richness of the grasslands [45, 46].

Overall the impact of agriculture on wildlife has been mixed, despite the trend towards a more extensive farming system. In lowland areas of meadows and grasslands, partridge, pheasants and hares are common but populations have been in decline (except pheasants) [3]. With the declining area under arable crops, some bird species that rely on this type of habitat are near extinction, such as the great bustard (*Otis tarda*), and corncrake (*Crex crex*), while the imperial eagle (*Aquila heliaca*) which also relies on agricultural land has been threatened with extinction [3]. This trend is of concern as farming was estimated to have posed a threat to around 45% of important bird habitats through changes in management practices and land use in the late 1990s [47].

3.24.3. Overall agri-environmental performance

Overall the environmental pressure from agricultural activities has declined since 1990. The transition to a market economy has resulted in a more extensive farming system, leading to: a decrease in the use of purchased farm inputs (fertilisers, pesticides, energy and water); lower water and air pollution; and the conversion of cropland to pasture [4]. With the small rise in farm input use since the late 1990s, water pollution in some intensively farmed areas has risen slightly. Even so, by 2005 farm input use remained below its peak of the late 1980s. Soil erosion is a major and widespread problem, partly because the share of arable land in total farmland is over 60%. With respect to biodiversity there are concerns over damage to semi-natural grasslands and the decline in farmland bird species.

Progress is being made toward establishing a agri-environmental monitoring system, to provide the information required to effectively monitor and evaluate agri-environmental performance and policies [3, 7, 48]. In some areas monitoring is well developed and established over a long period, notably the soil monitoring system managed by the Soil Science and Conservation Research Institute since 1993 [36], as well as ammonia and greenhouse gas emission monitoring [43]. An important area requiring improvement, however, is agri-biodiversity monitoring, but starting from 2001 the government is now beginning to establish indicators to better assess biodiversity trends [24]. With the recent introduction of agri-environmental schemes that address biodiversity conservation in agriculture, this information will be important to help evaluate the effectiveness of these schemes.

With the entry into the EU Slovak agri-environmental policies are being strengthened, but it is too early to assess the environmental outcomes from their implementation. The 2004 *Principles of National Soil Policy* establishes a framework for sustainable use and protection of

farmed soil against erosion, compaction and pollution [1, 4]. Agri-environmental programmes implemented since the early 2000s are planned to reintroduce some endangered bird species and address other concerns related to biodiversity, notably the conservation of semi-natural grasslands [3]. Recent policy priority has been given to promote organic farming through the 2005 *Action Plan for the Development of Organic Farming*, and meeting the obligations under the EU *Water Framework Directive* especially the *Nitrates Directive*.

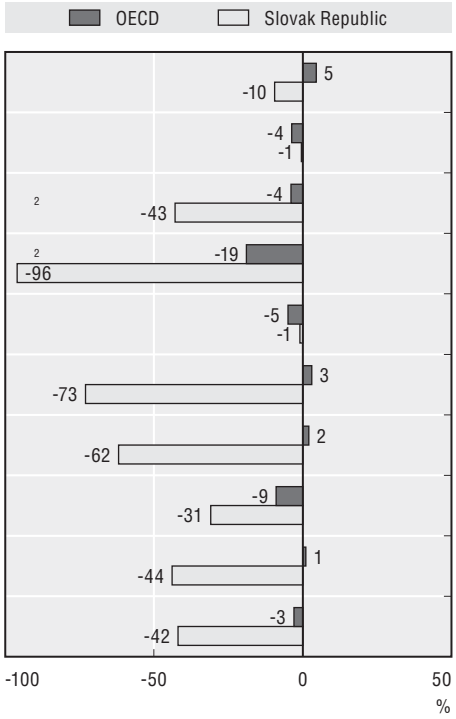
While the environmental performance of agriculture has improved since 1990 problems persist. With 47% (2002-04) of farmland affected by medium to extreme risk of ***soil erosion*** from water, soil conservation measures are inadequate to address the problem, with very low uptake of soil conservation practices. While the conversion of some arable land to grassland in areas at high risk of erosion is likely helping to lower soil erosion rates, greater investment in soil and other environmental farm management conservation practices is needed [4]. ***Tax exemptions*** on fossil fuel used by farmers provide a disincentive to improve energy efficiency and help further reduce greenhouse gas emissions, but this support has been reduced as have agricultural GHG emissions and energy consumption.

Wildlife has benefited from the conversion of cropland to grassland, as well as reduced pressure from agricultural water and air pollution on ecosystems, although there are few studies that have examined these changes. But there are concerns with the decline in numbers of certain endangered farmland bird populations and the abandonment to overgrowth of high nature value semi-natural grasslands. The key threats to high nature value semi-natural grasslands, include in some regions the switch to more intensive forms of management (*i.e.* higher stocking rates), but in other areas the reduction in livestock numbers leading to abandonment or under-grazing below a level sufficient to maintain the species richness of semi-natural grasslands [3, 4].

Projections of agricultural production up to 2010 indicate that overall the farming system is likely to remain at a significantly lower level of intensity compared to the 1980s, especially in terms of the use of purchased farm inputs, such as fertilisers, pesticides, energy and water [43]. Moreover, research into the likely impacts of EU membership on agricultural production up to 2010 reveals that overall production is expected to stabilise or slowly increase for both arable crops and livestock [49].

Figure 3.24.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

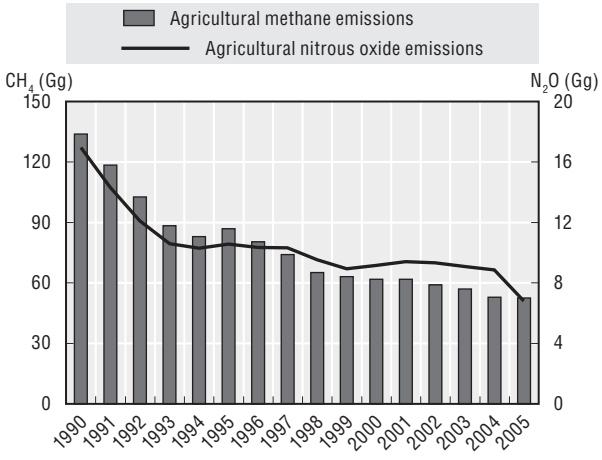
Variable	Unit		Slovak Republic	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	90	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–11	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	46	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	1	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–22	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–484	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–116	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	0.4	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–23	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–2 939	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

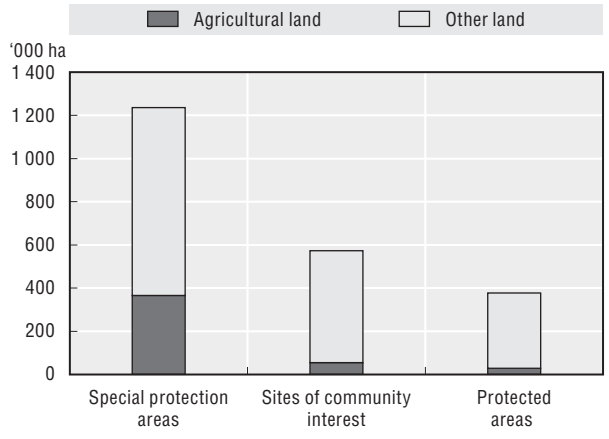
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.24.3. **Agricultural methane (CH_4) and nitrous oxide (N_2O) emissions**



Source: Slovak Environmental Agency (SEA).

Figure 3.24.4. **Share of agricultural land under different types of protected areas: 2003**



Source: Slovak Environmental Agency (SEA).

StatLink http://dx.doi.org/10.1787/301024707308

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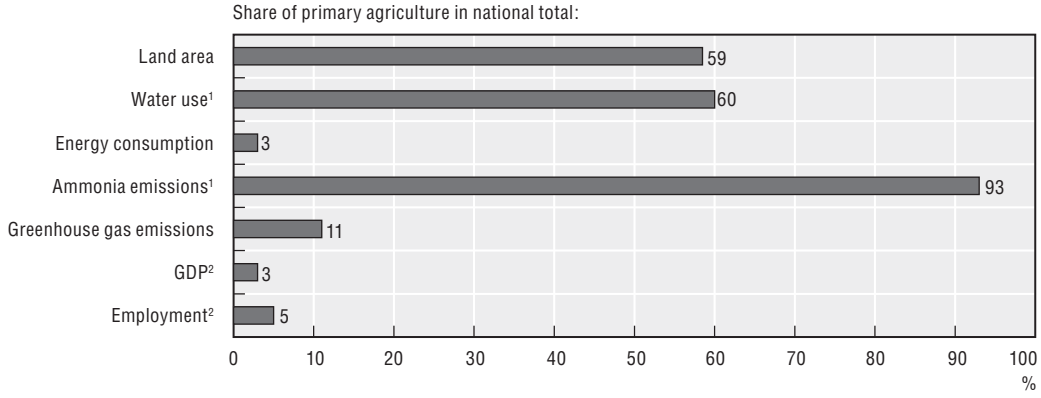
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3.25. SPAIN

Figure 3.25.1. **National agri-environmental and economic profile, 2002-04: Spain**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2003.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.25.1. Agricultural sector trends and policy context

Growth in agricultural production was among the highest across OECD countries, between 1990-92 and 2002-04 (Figure 3.25.2). But between 1990 and 2003 the share of agriculture in GDP declined from 5% to just over 3% and the share of farm employment in total employment from nearly 10% to 5% [1] (Figure 3.25.1). Agriculture's use of natural resources is significant and accounted for 59% of total land use (2002-04) and 60% of water use (2001-03) [1, 2].

Agricultural production is intensifying on a smaller area of land and is being concentrated in fewer farms [1]. The total area farmed declined by 3.5% between 1990 and 2004, compared to the average for the EU15 of over 5% [1]. During this time the use of farm inputs rose, resulting in higher agricultural productivity and the substitution of labour by purchased inputs since 1990. The rise in the volume of purchased farm inputs over the period 1990-92 to 2002-04 included: nitrogen (5%) and phosphate inorganic fertilisers (13%), pesticides (11%); on-farm energy use (39%) and water use (9%) (Figure 3.25.2). Underlying these changes has been greater regional specialisation in production [3] and a shift from crop to livestock output, with the volume of livestock production rising by nearly 37% (for all livestock types except dairy cows) compared to an increase of 22% in crop production between 1990-92 and 2002-04. Even so, crop production contributes the major share of the total value of agricultural production (over 60% in 2003), and for some crops output has risen more rapidly than for livestock, especially for irrigated crops including olives, vine and horticultural products [1].

Farming is mainly supported under the Common Agricultural Policy (CAP) with support also provided through national expenditure within the CAP framework. Support to EU farmers on average declined from 41% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate – PSE) compared to the 31% OECD average. Nearly 70% of EU support to farmers was output and input linked in 2002-04 (compared to over 90% in the mid-1980s), the forms of support that most encourage production [4]. Total budgetary support to Spanish agriculture including EU funding was over EUR 6 (USD 7.5) billion in 2004, of which 25% was nationally financed. Agri-environmental measures in Spain accounted for 4-5% of budgetary support in 2004 [5].

Agri-environmental policies have been strengthened since their introduction in 1992 [5, 6, 7]. During the financial period 2000-06, the agri-environmental measures were included inside a national rural development programme. Their main objectives were targeted to achieve a sustainable agriculture and the protection of biodiversity and landscape. The priorities for agri-environmental policies are divided into five areas which cover: water, soil, natural risks, biodiversity and landscape. There are nine different measures related to these areas, including: extensive production; local varieties threatened with genetic erosion; environmental measures for the rational use of chemical products; prevention of soil erosion; protection of wetlands ecosystems; reducing water abstractions and enhancing extensive production; landscape protection; fire prevention; and livestock farm management for the conservation of natural resources. The expenditure on agri-environmental measures for the 2000-06 period was EUR 1.2 (USD 1.5) billion, of which 70% was EU-funded.

National water policies are important for the agricultural sector. Over the past 20 years water policy has evolved through three key phases: first, the *Water Act* from 1985 to 2001; second, the *National Hydrological Plan (NHP)*, 2001-04 and the *National Irrigation Plan (NIP)*, 2002-08; and third the *AGUA* (Actions for the Management and Use of Water) programme, from 2004 to the present. The ***Water Act*** established the institutional framework for water management by creating 15 *River Basin Authorities* (RBAs), each of which design their own hydrological plans, with the first plans established in 1998 for a 10 to 20-year period [5, 7, 8, 9, 10]. The *NHP and AGUA programmes* were introduced with the main objective of resolving water scarcity and degradation problems through subsidised investments in water infrastructure. The *NHP project* aimed to balance national water abundance and deficits, by transferring water from the "abundant" Ebro water basin in the north to the "deficit" water basins in the south as far as Almería, 700 km from Ebro [5, 11, 12]. The new government in 2004 approved a modification of the *NHP*, under the *AGUA programme* which aims to address water scarcity through mainly constructing desalinisation plants drawing on the brackish coastal aquifers in the south, and abolishing the plan to transfer water from the Ebro to the Segura [13, 14]. The project involves investing up to EUR 3.8 (USD 4.8) billion on desalination facilities, with about a third of the additional freshwater capacity intended for irrigation [13]. *AGUA* will also enforce stricter regulations on over extraction of aquifers [14].

The National Irrigation Plan is seeking by 2008 to reduce irrigation water use by 10% from 2002 levels by upgrading existing irrigation infrastructure and developing new irrigation schemes involving a 7% growth in the total irrigated area from 2002 [5, 13, 15, 16]. This is estimated to cost EUR 5 (USD 6.3) billion between 2002 and 2008, with 50% funded publicly (EU, national regional funds) and 50% by farmers using long term loans [16, 17]. Since the 1999 revisions to the *Water Act* irrigators are in principle required to meter water use with *water charges* covering full costs (operation, maintenance, and amortisation of

capital). Where irrigators' water use is above the allocated volume of water, this may lead to higher water prices, whereas use below expected levels can result in lower prices [5]. In practice, however, RBAs collect under 20% of irrigation costs [5].

Agriculture is implicated by other national environmental and taxation policies. Farmers benefit from a ***fuel tax concession*** equivalent to nearly EUR 65 (USD 81) million of tax revenue forgone in 2005. Support was provided in 2004 to compensate for higher oil prices, with a payment per litre of fuel consumed up to a maximum of EUR 3000 (USD 3750) per farmer [4]. Some payments are provided to farmers to renew old machinery with less polluting and more energy efficient machinery [4]. The *Plan for Developing Renewable Energy* (2000-10) and the *Plan for Improving Transport Infrastructure* (2000-07) seek to encourage production and domestic consumption of bioenergy (fuels and power generation), involving the use of some domestically produced agricultural biomass and by-products as a feedstock [5, 17]. Measures include support for the capital costs of bioenergy plants, zero taxation on biofuels and favourable feed-in tariffs for generation of renewable electricity production [17].

International and regional environmental agreements are also important for agriculture. They include those seeking to curb nutrient emissions into the Atlantic (*OSPAR Convention*); lower ammonia emissions (*Gothenburg Protocol*) and eliminate methyl bromide use (*Montreal Protocol*). In addition, Spain is a signatory to the *UN Convention to Combat Desertification*, and has adopted the *National Action Programme to Combat Desertification* that expands efforts to control soil erosion, including EUR 1.2 (USD 1.6) billion for agri-environmental measures and EUR 900 (USD 1 125) million for farm forestry [5]. Under the UN *Convention on Biological Diversity* the national *Biodiversity Strategy* (1998) aims to promote biodiversity by developing sectoral plans, including for agriculture and forestry. Conservation programmes such as the *Specifically Protected Areas* (SPA) and *Sites of Community Interest* (SCI) encompass agricultural land [5]. Spain has a number of environmental co-operation agreements with France and Portugal, notably concerning water resources, with nearly half of Portugal's renewable freshwater resources originating in Spain [4]. The *Convention on the Co-operation for the Protection and Sustainable Use of Waters of Portugal and Spain River Basins* (2000), covers water quality and resource use, and defines minimum flows for transboundary river basins [5, 18, 19].

3.25.2. Environmental performance of agriculture

The key agri-environmental challenges are the management and conservation of soils, water resources, biodiversity and cultural landscape features. Other important agri-environmental issues include controlling agricultural water pollution, and lowering ammonia and greenhouse gas emissions. Spain is characterised by great geographical, climatic and agri-ecosystem variety [1, 5]. Almost 60% of the mainland is above 600m in altitude. About a third of the country has an oceanic climate with frequent rainfall, while much of the rest has a Mediterranean or semi-arid climate, frequently affected by droughts. Nearly 40% of the farming population and 80% of farmland is situated in less-favoured areas among which are the mountainous regions threatened by depopulation, where semi-natural low intensity farming systems and areas with special natural characteristics predominate [1].

A major share of agricultural land is subject to moderate to extreme risk of soil erosion, among the highest share across OECD countries [2, 20]. Nearly 50% of agricultural land during 1987 to 2000 was estimated at moderate to extreme risk to ***water erosion*** (from 12 to > 200 tonnes/hectare/year), with more than 70% of arable and permanent cropland at

moderate to extreme risk of erosion. About 15% of arable and permanent cropland is at high to extreme risk of erosion (greater than 50 tonnes/hectare/year), but this is restricted to specific areas with steeper slopes and usually occurs only after ploughing or the abandonment of farmland [20]. It has been estimated that ***wind erosion*** has only been reported in more localised areas, such as in the north-west and southern coastal areas [20]. The high soil erosion risk potential is largely attributed to frequent dry periods followed by outbreaks of heavy rain, particularly in southern regions, where there are also fragile soils and thin vegetation cover. In addition, poor soil management practices and land use changes, including abandonment of farmland and conversion from forests to pasture have contributed to increased rates of soil erosion [20, 21, 22]. But the abandonment of olive groves, vineyards and other crops in areas of low soil fertility, however, has also been shown to enhance soil degradation in some areas [20, 21].

Off-farm erosion effects are considered of greater significance than on-farm. Aside from extreme events, the main consequence of soil erosion off-farm includes silting of reservoirs, lakes and rivers, and exacerbating landslides and flooding [20]. An assessment in 1986 estimated that the off-site costs of soil erosion from all land were about EUR 173 (USD 170) million annually [20]. Erosion control criteria were incorporated into schemes eligible for agri-environmental payments in 2000, such as low or no tillage, summer cover crops and use of seeded fallow [2, 5, 23]. While conservation and no-tillage began in the early 1980s, adoption has been limited, although the practice of stubble burning was banned in 2001.

Overall pollution of water bodies by agriculture is widespread and growing [5, 24]. The agri-food industry was an important but not the major source of direct water pollution across the economy in 1997, accounting for 7% for nitrogen, 7% for phosphorus and 2% for metal pollutants [24]. The potential risk of water pollution from run-off and leaching of agricultural nutrients, pesticides, and heavy metals is increasing with the rise in nutrient surpluses and pesticide use. The growth in irrigation is leading to greater return flows containing pollutants and higher salinity through the over extraction of aquifers [25]. Farm pollution of rivers is less severe than for lakes, reservoirs (many of which are eutrophic) and groundwater where quality is continuing to decline in some areas, particularly caused by nitrates, salts and pesticides.

Agricultural nutrient surpluses increased between 1990-92 and 2002-04 (surpluses are the quantity of nutrient inputs minus outputs of nutrients, nitrogen – N – and phosphorus – P). Over this period the quantity of N surplus increased slightly by 1% compared to a decline of 21% for the EU15, while the P surplus increased by 18%, but for the EU15 decreased by 43% (Figure 3.25.2). Despite the rise in nutrient surpluses, the quantity of surplus per hectare of agricultural land was considerably lower than the EU15 and OECD averages. There was little change in nutrient use efficiency (the ratio of N/P output to N/P input) over the period 1990-92 to 2002-04. The increase in nutrient surpluses is mainly due to higher growth in inorganic fertiliser use and manure (from higher livestock numbers, especially, cattle, pigs and poultry).

Agriculture's nitrate pollution of groundwater is a serious concern. Nitrate pollution of groundwater is widespread and is mainly caused by the agricultural sector, which accounts for 80% of total groundwater use. Around 21% of monitored aquifers have nitrate concentrations above the *EU Drinking Water* standard (> 50 mg/l) compared to less than 1% for surface water in 2002-03 [2]. Over the 1990s concentrations of nitrates were stable in about 30% of aquifers, decreased in around 30% and increased for the remaining 40% [5].

Agricultural pollution of groundwater is more significant in Mediterranean areas where nitrate concentrations above 100 mg/l are not uncommon [26, 27]. It was reported in 2003 that only one coastal area was potentially subject to eutrophication from nitrogen and phosphorus [5]. There has been some improvement in nutrient management with effluent that was formerly discharged directly into water courses now being diverted to settling ponds and then spread onto farmland and forest soils.

The growth in pesticide use on farms is increasing groundwater pollution pressures. Pesticide use (tonnes of active ingredients) declined from the mid-1980s to the mid-1990s but steadily grew up to 2004 (Figure 3.25.2), in part due to the 22% growth in the volume of crop production between 1990-92 and 2002-04. The rise in pesticide use was in comparison to a reduction for the EU15 and OECD averages over the same period. There is no systematic regular monitoring of pesticides in water bodies, but various studies report their increasing presence in groundwater largely as a direct result of farming activities [5, 26, 28]. Irrigation has resulted in the contamination of aquifers, in some cases in excess of *EU Drinking Water Standards*, such as the water basins of Tajo, Guadiana, Guadalquivir, Sur, Júcar and Catalonia [5, 26]. In addition, some organochlorine pesticides, which have been restricted or prohibited since the late 1970s/mid-1980s (*e.g.* DDT, dieldrin, lindane), were still being detected in soils, water, foods and people up to the early 2000s, due to their persistence in the environment [28, 29].

Recent trends in farming practices and systems could lower pesticide use. The share of arable and permanent crops under ***non-chemical pest control methods*** (*e.g.* crop rotation, manual weeding) and integrated pest management (*e.g.* using pest resistant crops, enhancing natural enemies) rose from 3% in 1990 to 8% by 2000 [1, 2]. The area under ***organic management*** has expanded rapidly from a very few farms in the early 1990s to 8% of total agricultural land by 2005 (Figure 3.25.3) [1, 2, 30]. The main organic crops (by area) include cereals, olives, and horticultural crops, while there has also been an increase in organic livestock production, especially cattle, sheep and goats [1]. The growth in the use of insecticides could also be reduced with the expansion in ***transgenic Bt maize production*** [31]. Since its introduction in 1998 the area under Bt maize rose to over 10% of the total maize area by 2005, the largest area of transgenic crops across the EU15 in 2005 [31, 32].

Agricultural water use grew twice as rapidly as total water use across the economy between 1990-92 and 2001-03 (Figure 3.25.2). As a result, farming accounted for 60% of total water use in 2001-03 [2]. Much of the increasing use of water by agriculture has arisen because of the 8% growth in area irrigated from 1990-92 to 2001-03, contributing to over a quarter of the EU15 total irrigated area by 2001-03. By 2001-03 the irrigated area accounted for 9% of farmland, almost 100% of total farm water use, between 50-60% of the final value of agricultural production and 80% of farm exports [1, 16, 33]. The expansion of the olive, vine and horticulture sectors has been a key driving force in demand for irrigation. On average about 80% of the irrigable area (*i.e.* area with irrigation infrastructure) is irrigated annually [16, 34]. The main source of water for irrigation is surface water (75-80%), with groundwater accounting for much of the remainder, while the share of irrigation in total groundwater use is about 75-80% [8, 16]. In some eastern coastal areas and the Spanish islands, however, recycled water and desalinisation are becoming important ways to meet the demand for water by irrigators and other users [14, 16].

There is widespread over-exploitation of aquifers from irrigation and other users, especially the tourist industry and urban centres along the Mediterranean coast [5, 18]. Around 13% of the irrigated area extracts water from aquifers that are over-exploited or in danger of

saltwater intrusion [16, 35]. The over extraction from aquifers has led to problems of increasing salinity and reduced river flows to the detriment of aquatic ecosystems, especially in southern river basins [5, 9, 13, 33, 36]. Water abstractions by irrigators not registered have contributed considerably to the problem of the over-exploitation of aquifers [5, 9, 13, 37]. It has been estimated that around 45% of water pumped from aquifers is extracted without registration mainly for irrigation, but also for urban use and the tourist industry [35, 37], with up to 90% of private wells not correctly registered [9]. Irrigation water application rates (litres per hectare of irrigated land) decreased by 5% between 1990-92 and 2001-03, compared to the decrease of 9% for the OECD on average. This improvement in irrigation water use efficiency is in part explained by the increase in the share of irrigated area under the more efficient drip-emitter water application technologies, which rose from 9% in 1989 to 31% in 2001-03 [2]. In 2002 about 20% of the irrigated area was supplied water through earth ditches, while under 30% of the irrigation infrastructure is less than 20 years old [34, 38].

Air pollution trends linked to farming have shown mixed trends. Agricultural ***ammonia emissions*** rose by 21% between 1990-92 and 2001-03, among the highest rates of growth across OECD countries, mainly as a result of the increase in livestock numbers and nitrogen fertiliser use. Farming accounted for 93% of total ammonia emissions in 2002-04 (Figure 3.25.2). Spain has agreed to cut total ammonia emissions to 353 000 tonnes by 2010 under the *Gothenburg Protocol*. By 2001-03 total ammonia emissions were 389 000 tonnes, so a further 10% cut will be required to meet the target under the Protocol. While it is likely that the growth in farm ammonia emissions has contributed to an overall rise in acidifying pollutants, increasing pressure on ecosystems (terrestrial and aquatic) sensitive to excess acidity, there is little research or data available. For ***methyl bromide*** use (an ozone depleting substance) Spain, along with other EU15 countries, reduced its use over the 1990s as agreed by the phase-out schedule under the *Montreal Protocol*, which sought to eliminate all use by 2005. Since 2005 Spain has agreed to reduce annually "*Critical Use Exemption*" (CUE), which under the *Protocol* allows farmers additional time to find substitutes, with CUEs reaching 252 tonnes in 2007, (ozone depleting potential), or about a half of the EU15's CUEs. Methyl bromide is permitted in strawberry and flower crop production, as well as research, especially as a soil fumigant.

Growth in agricultural greenhouse gas (GHG) emissions was the highest across OECD countries, rising by 18% between 1990-92 and 2002-04 (Figure 3.25.2). This compares to a reduction of –7% in agricultural GHG emissions for the EU15, and a 41% rise in total GHG emissions for the Spanish economy as a whole [39]. Under the *Kyoto Protocol* and the EU *Burden Sharing Agreement* Spain can increase its total GHG emissions up to 15% by 2008-12 from the 1990 base year [39]. The share of farming in national GHG emissions was 11% in 2002-04 with the main sources and growth of agricultural GHGs from methane (from livestock) and nitrous oxide (from fertilisers and manure applied on soils) [39]. As a result of the policy measures taken in order to control GHGs, agricultural GHGs are projected to decline by 2% from 2005 to 2010 [39]. Over the period 1990 to 2008-12 estimates suggest that changes in farm management practices and farmland use could lead to an increase in ***carbon sequestration*** equivalent to about 25% of agricultural GHGs in 2000-02 [2]. Almost 60% of the carbon sequestration is expected to occur from afforestation of farmland, with a further 10% from the change to conservation tillage [2].

The rise in direct on-farm energy consumption of 39% was below the 54% rise across the economy, over the period 1990-92 to 2002-04 (Figure 3.25.2). Rising energy consumption has contributed to higher GHG emissions. Farming accounted for about 3% of total energy

consumption in 2002-04 and projected growth in farm production could see energy consumption rise unless energy efficiency gains are realised. Much of the rise in direct on-farm energy consumption, the highest rate of growth across OECD countries, is explained by the expansion in use and size of machinery as a substitute for labour over the past 15 years.

A central element of the Plan for Developing Renewable Energy (2000-10) is the expansion of biomass to produce bioenergy (electricity and biogas) from agricultural, forestry, industrial and other feedstock sources [17]. Biogas production has been expanding and biofuel production capacity almost met 50% of the 2010 target by 2004, with Spain now one of the major bioethanol producers in the EU [17], although the production of biomass to generate power has fallen behind the government's target [17].

Overall the adverse pressure from agriculture on biodiversity has increased since 1990, but disentangling the impacts due to farming activities and related land use changes is complex and hampered by a lack of data. However, there are two diverging trends. On the one hand, the intensification of production with an increase of pollutants into the environment, especially nutrients, pesticides and ammonia emissions, has increased pressure on terrestrial and aquatic ecosystems, and degradation of habitats through soil erosion, flooding for irrigation, and the reduction of water flows in rivers. On the other hand the conversion of semi-natural farmed habitats mainly to shrub, forestry, and urban development has also led to adverse effects on biodiversity. The abandonment of low intensity grazing in some semi-natural habitats, for example, has caused the loss of more than 60% of grassland species [40]. Some farmland use changes, however, may have a beneficial impact for biodiversity, including the increase in farm fallow land and farm woodland, which together accounted for 22% of total farmland by 2000-02 compared to 19% in 1990-92 [2].

Agricultural crop and livestock genetic resource diversity increased between 1990 and 2002, suggesting greater environmental resilience of farming systems. The diversity of most ***crop varieties*** used in production rose during this period, but maize was a notable exception although some local varieties of maize were not included in the statistics [2]. Similarly for ***livestock breeds*** there was an increase in the numbers (diversity) of officially recognised breeds, domestic and foreign breeds, used in marketed production, from 88 in 1979 to 169 in 2007. *In situ* conservation of local breeds is growing in importance, with most breeds having recognised breeding associations, supported by a regional network, largely government-funded, of *ex situ* collections of animal genetic material. Despite these changes there was an increase in the number of officially recognised critical and endangered livestock endogenous breeds from 19 to 117 breeds between 1979 and 2007, with most of them under conservation programmes [2]. In some cases the conservation of certain breeds, notably the protection of the Iberian Pig (*Cerdo Ibérico*) and several domestic ruminant breeds, has brought with it not only a source of income through the sale of high quality cured hams, meats and cheese, but has also formed an integral part of ecosystem diversity conservation. The Iberian pig has adapted over the centuries to feed on the acorns from the oak trees in the semi-natural grazed Dehesa habitats [41, 42].

Converting agricultural land to other uses puts pressure on biodiversity conservation, especially in the case of semi-natural farmed habitats [6]. Relative to other EU15 countries Spain has a high proportion of farmland designated as ***semi-natural habitat*** subject to extensive management practices, including: lowland Steppes (where poor soils have constrained more intensive cultivation); mountain areas, ranging from terraced olive

groves in the south to hay meadows in the Pyrenees to the north; and some lowland rivers and wetlands [15]. An important farmed semi-natural habitat in Spain is the ***Dehesa***, a habitat system common to Mediterranean Iberia (Figure 3.25.4). The Dehesa is a system created by human land use and management, mainly based on extensive stockbreeding farming in an area of mixed pastures and Mediterranean forest vegetation. More than 20% of the area has to be covered with leafy species, with a rate of tree cover of between 5% and 60%. These characteristics lead to an ecosystem with high environmental value, sustainable use of land, and a balance between landscape and the diversity from the integration due to agriculture and forestry management.

Farmed semi-natural habitats are rich in biodiversity and are associated with several of Spain's emblematic endangered species, such as the Iberian Lynx (*Lynx pardinus*), Spanish Imperial Eagle (*Aquila adalberti*), Black Vulture (*Aegypius monachus*) and Black Stork (*Ciconianigra*) [15, 40]. But these habitats are subject to a variety of threats, including: their abandonment to shrub reducing their value for many species of flora and fauna [22, 40, 43]; conversion to use for forestry; greater use of chemical inputs in some cases (such as mountain olive groves); overstocking of livestock in certain areas,; and pollution of rivers.

The expansion of irrigation has had adverse impacts on ecosystems. In southern regions semi-natural farmed habitat has been converted to areas of intensive irrigation with adverse consequences for terrestrial species [44]. The rising demand for water in newly irrigated areas has also led to the diversion of water for irrigation lowering flows in rivers and wetlands, and chemical run-off polluting aquatic ecosystems [5, 15, 36, 37, 44, 45]. But some research has shown that under certain management conditions irrigation pools for holding water for drip irrigation (*e.g.* using sand and gravel instead of plastic as construction materials), can provide habitats for some species, including aquatic plants, water birds, fish and amphibians [44, 46].

The change and loss of semi-natural farmed habitats has been detrimental to bird populations. Although data are limited, trends in farmland bird populations declined between 1997 and 2002. Moreover, the importance of farming practices on bird populations is also revealed by the BirdLife International Important Bird Areas (IBAs) indicator, defined as prime bird habitat. The indicator shows that around 35% of the most significant threats to Spanish IBAs originates from farming, including not only production intensification but also the loss of semi-natural farmed habitat to other uses, while the construction of irrigation projects threatens around 40% of IBAs [47]. Winter stubble maintenance is included as a compulsory commitment under some agri-environmental programmes, in part to help reduce soil erosion.

The conversion of semi-natural farming systems to other uses threatens cultural landscape conservation. The abandonment of semi-natural farmed areas to garrigue or shrub or their conversion to other uses (*e.g.* irrigation or forestry) is also a concern for cultural landscape conservation, including the neglect and damage to features such as stone walls, terraces and historic farm buildings [15]. The changing spatial characteristics of semi-natural landscapes through abandonment are also considered to have reduced the structure and heterogeneity of landscapes and hence diminished their aesthetic value [22, 48]. Socio-economic changes also alter cultural landscapes in agricultural areas, especially through changes in farming practices, such as the reduction in transhumance leading to the disappearance of drovers' tracks and loss of farmer knowledge related to hedge and terrace maintenance [48, 49]. The Ministry of Environment together with regional governments is beginning to establish an

inventory of drovers' tracks in recognition of their value to some livestock systems, biodiversity and cultural landscapes [5].

3.25.3. Overall agri-environmental performance

Overall the pressure on the environment from agriculture has increased since 1990. This largely results from both the rapid growth in agricultural production (among the most rapid in the OECD area), and the greater use of purchased inputs on a declining farmed area. As a result, the intensity of farming is growing with increasing use of nutrient fertilisers, pesticides, water, and energy. Compared to many other EU15 countries, however, Spanish agriculture is in general more extensive. However, soil erosion and water scarcity and pollution are the main environmental problems caused by agriculture. The conservation of biodiversity and cultural landscapes in agriculture and the increase in ammonia and greenhouse gas emissions are also growing environmental challenges related to agriculture.

There is a lack of data and indicators to adequately monitor and evaluate agri-environmental performance and policies. Improving the collection and maintenance of databases would provide information for policy makers to better monitor agri-environmental policy measures and evaluate their environmental effectiveness. The government, however, is beginning to establish databases. For example, in 2002 the Ministry of the Environment embarked on a 10 year project to establish a new national soil erosion inventory to improve national estimates of ***soil erosion*** risks [2, 20]. The knowledge base on ***biodiversity*** is also being strengthened with recently published inventories of flora and fauna and their habitats [5]. But River Basin Authorities' task of managing and regulating water, especially extractions not registred from groundwater, is being impeded by a lack of reliable information of how much ***water***, where, and at what rate it is being abstracted and recharged by agriculture, and what the long term environmental implications might be [8, 14, 50]. Moreover, there is no systematic monitoring of agricultural ***pesticide*** pollution of water bodies, and there is little information on the impact of agricultural ***ammonia*** emissions on ecosystems.

The government has begun the task of addressing environmental problems in agriculture with the introduction of agri-environmental policies in 1992. But there has been a relatively low uptake of agri-environmental schemes in Spain compared to many other EU15 countries. For example, in 2002 less than 10% of agricultural land was included under such schemes compared to over 20% for the EU15 on average [51]. This is partly explained by budgetary restrictions; the predominant attitude among farmers to raise production without attention to environmental stewardship; and high transaction costs [7]. By the end of 2004, however, over 50% of the target under the 2000-08 *National Irrigation Plan* to upgrade the irrigation infrastructure had been achieved with water savings estimated at 4% of the total irrigation water used in 2001-03 [16, 34].

The projected growth of farm production up to 2008-12 may further increase environmental pressure, in particular, from the anticipated rise in livestock numbers, fertiliser use and irrigated area [52]. ***Soil erosion*** is a key agri-environmental problem, to address this issue a number of measures are being taken, such as agri-environmental measures, cropland afforestation and forest fire prevention [53]. Concerning curbs on the growing ***pollution from agricultural nutrients*** under the *EU Nitrates Directive*, only a relatively small share of farms (about 15%) and farmland (nearly 10%) were under agri-environmental measures that include nutrient management commitments in 2001-03 [2, 5]. ***Fuel tax concessions*** and

support provided to compensate for higher oil prices for farmers undermine incentives to more efficiently use energy and may lead to higher GHG emissions, which is of particular significance as agricultural GHGs have been increasing.

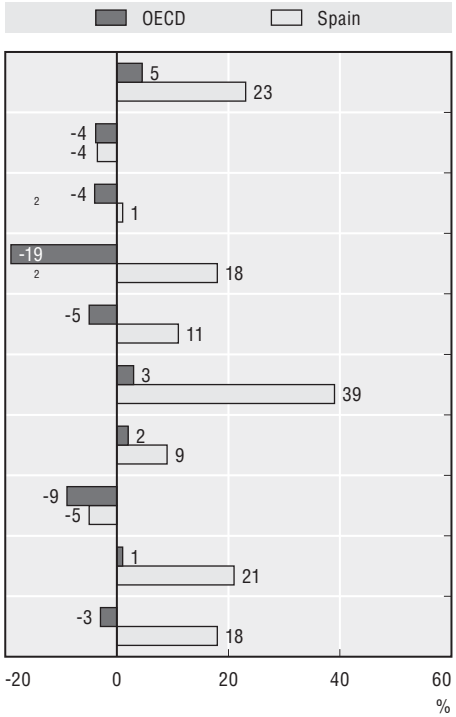
The expansion of biomass (including from agricultural feedstock) has fallen behind the targets set for 2010 under the Plan for Developing Renewable Energy, with the collection and transport of biomass thus far poorly developed [17]. With the increase in ammonia emissions, which are produced mainly by agriculture, Spain will have to make substantial reductions in agricultural emissions to meet both commitments under the Gothenburg Protocol by 2010 and the more stringent target under the EU *National Emission Ceilings* [5]. There has been some success in reducing ***methyl bromide*** use to meet commitments under the *Montreal Protocol*, while since 2005 an annual reduction of Critical Use Exemption (CUEs) has been agreed for Spain. CUEs have been assigned to strawberry and flower crops, and for research activities. Biodiversity is under serious threat from agriculture, and agri-environmental measures could be strengthened to address this problem [5]. Examples include altering management practices for irrigation pools [45], and limiting herbicide application on winter fallow [54].

Farmers have little incentive to conserve water resources given the support provided to water charges and irrigation infrastructure costs. In addition, the cost of water for irrigators has typically represented only a small share of their annual variable costs (*e.g.* labour, fertilisers, pesticides, seeds and plants), limiting the use water more efficiently [14, 55]. But the control of water charges by largely regional authorities instead of by water users, also leads to excessive use. While the expansion in the area irrigated has been a key driving force in the socio-economic expansion of many areas, especially in the south-east, the pace of development has led to water demand exceeding availability leading to water scarcity, over-exploitation of groundwater and increasing salinisation, and damage to aquatic ecosystems by from reduced water flows to wetlands and rivers [14, 33]. The competition for water resources has been exacerbated by growing demand not only from farming but also from tourism and urban development, particularly along the Mediterranean coast [14, 35].

The AGUA programme brings with it potential environmental problems, as it seeks to address water scarcity by focusing on supply (mainly through desalinisation) rather than demand (price of water). This stems from the fact that farmers are pumping water from aquifers at prices that are as much as 3-5 times lower than the cost of desalinated water [13]. As a result of this, and in the absence of subsidies to farmers to purchase the higher priced desalinated water, better quality desalinated water could be mixed with lower quality water from coastal aquifers (that are often brackish), further exploiting aquifers. This may also encourage further illegal extraction of groundwater unless the use of aquifers is strictly enforced [13, 14]. Desalinisation also requires considerable quantities of energy. In the Canary Islands, for example, 14% of all energy demands were for seawater desalinisation in the early 2000s period [14]. Moreover, the environmental impacts from desalinisation on aquatic ecosystems are unclear [14].

Figure 3.25.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

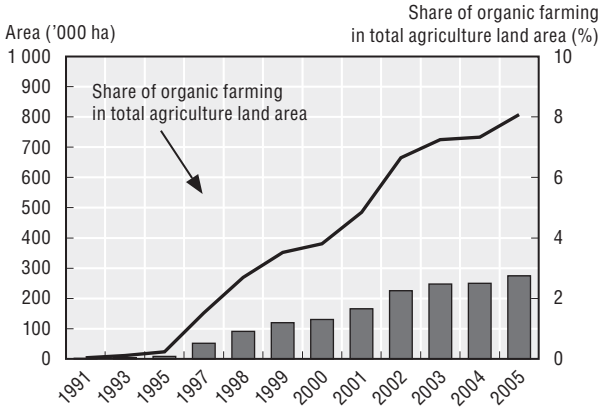
Variable	Unit		Spain	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	123	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–1 054	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	33	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	8	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	+3 933	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+707	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+1 740	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	7.0	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	+67	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	+7 265	–30 642

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

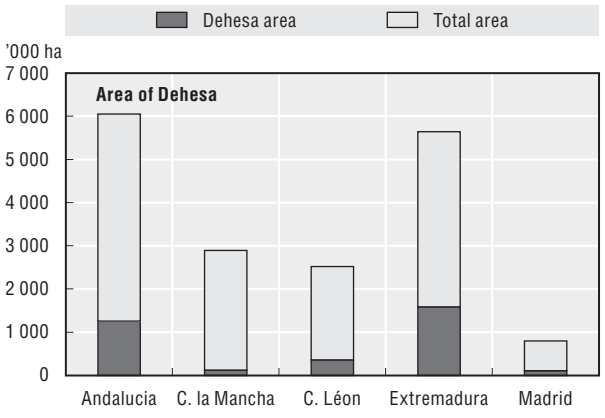
Figure 3.25.3. **Area of organic farming**



Source: Ministry of Agriculture, Fisheries and Food, Spain.

Figure 3.25.4. **Share of Dehesa area in total land area for five regions**

2006



Note: The dehesa is mainly located on traditional agricultural areas such as the Castilian plateau or the Sourthern part of Spain.

Source: Ministry of Agriculture, Fisheries and Food, Spain.

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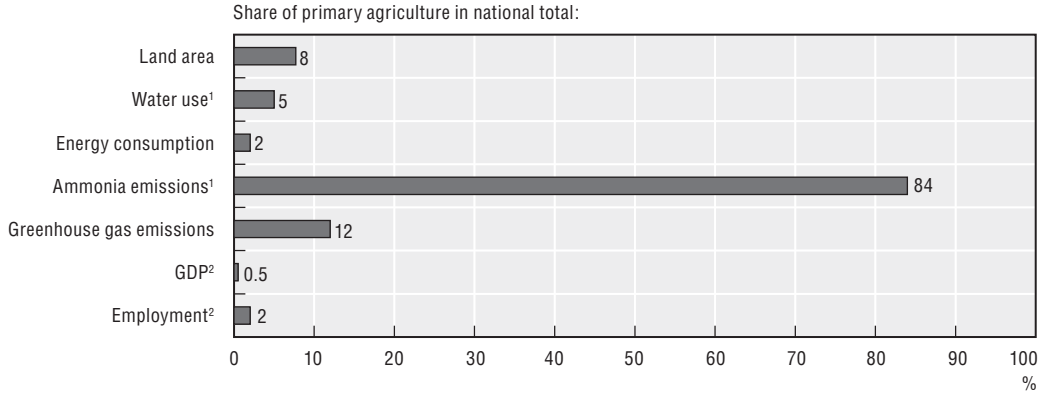
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3.26. SWEDEN

Figure 3.26.1. **National agri-environmental and economic profile, 2002-04: Sweden**



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1. Data refer to the period 2001-03.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.26.1. Agricultural sector trends and policy context

Primary agriculture's contribution to the economy is small and declining, accounting for 0.5% of GDP and less than 2% of employment in 2004 [1] (Figure 3.26.1). Agricultural production rose slightly by 3% over the period 1990-92 to 2002-04, due to an increase in livestock production (but livestock numbers declined), as overall crop production remained unchanged. While the area farmed declined by 6% between 1990-92 and 2002-04, the intensity of farm input use diminished with reductions in the use of: nitrogen (–11%) and phosphorus (–33%) fertilisers; pesticides (–3%); and on-farm direct energy consumption (–15%) (Figure 3.26.2).

Since accession to the EU in 1995 farming has undergone significant structural change [2]. The key developments between 1996 and 2005 include a reduction in the number of farms (–17%), an increase in farm size, and greater specialisation, mainly in dairying, pigs and cereals [1, 2]. Most farms are family owned and farming and forestry are often combined activities. The share of agriculture in the total land area, of about 7%, is among the lowest across the OECD area, because Sweden's climate and topography limit the growing season in the north. As agriculture is mainly rain-fed its use of water resources is small, accounting for only 4% of total water use in 2000 [3], which also reflects the very limited area irrigated, less than 2% of the total agricultural land area (2002-04), although in dry years the irrigated area can be more than double this share.

Farming is mainly supported under the Common Agricultural Policy, but also through national expenditure within the CAP framework. Support to EU15 agriculture declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate) compared to the OECD average of 30% [4]. Nearly 70% of EU15

farm support is output and input linked, but this share was over 98% in the mid-1980s. In addition to EU support, the total Swedish farm budget was EUR 12.2 (USD 15.3) billion or almost 30% of agricultural gross value added in 2004 [4]. Following the reform of Swedish agricultural policy in the early 1990s this led to a reduction of farm support between 1991 and 1996 [5], but since joining the EU in 1995 agricultural support increased [4, 6].

Integration of environmental concerns into agricultural policy have increased since joining the EU, especially under the *Environmental and Rural Development Programme* (ERDP, 2000-06), which is based on the EU's *Rural Development Programme*, [7]. About 80% of expenditure under the ERDP is for agri-environmental programmes including less-favoured areas, with the main focus on: reducing *nutrient pollution* into water bodies; the conservation of biodiversity and cultural landscapes; and support for organic farming [4, 7]. The key measures to reduce nutrient leaching under the ERDP include payments for catch crops and spring tillage, bufferzones, and wetlands. Annual payments over the period 2000 to 2006 were for catch crops SEK 900/hectare (EUR 95); spring tillage SEK 400/hectare (EUR 45); bufferzones SEK 3 000/hectare (EUR 325); and wetlands SEK 3 000/hectare (EUR 325). Support for wetlands is also, in part, to cover costs for their establishment. *Biodiversity payments* vary between SEK 410 and SEK 6 600 per hectare (EUR 35-710) and are provided on condition that, for example, land is cleared of undergrowth and maintained on an annual basis so that no detrimental amount of growth accumulates. *Landscape conservation payments* vary between SEK 205 and SEK 400 per hectare (EUR 20-45) and are provided for ley pasture production on condition that the land is not subject to pesticide use nor tilled for at least 2 years [7, 8]. This payment is not granted to farmers in the most productive areas of Sweden. Annual ***payments to support organic production*** vary between SEK 500/hectare and SEK 7 500/hectare (EUR 55-810) for crops and SEK 1 700/hectare (EUR 180) for livestock production. Within the ERDP agri-environmental training expenditure is mainly directed (2005) at nutrients and pesticides SEK 67 (EUR 7) million, biodiversity SEK 36.5 (EUR 4) million, and organic farming SEK 34 (EUR 3.5) million [9].

Voluntary environmental schemes are common.There is widespread farmer adoption of voluntary environmental schemes, which require that certain environmental practices are achieved by farmers. The *Eco Audit Scheme* (now covering 70% of farmland and 90% of the value of production) helps farmers track their adoption of environmental practices. The *Integrated Production Scheme* for horticultural producers and the *Seal of Quality Scheme* involve stricter environmental requirements than the *Eco-Audit* [10, 11].

Agriculture is affected by national environmental policies. Since 1985 environmental concerns have been one part of agricultural policy, with specific plans of actions covering pesticides, nutrients, biodiversity and organic farming. Agri-environmental policies were further strengthened when the Swedish Parliament established 16 Environmental Quality Objectives (EQOs) with long term objectives to 2020 and about 70 interim targets [12, 13, 14]. Some of the EQOs concern agriculture, including objectives for a varied agricultural landscape, zero eutrophication, and a non-toxic environment (*i.e.* reducing pesticide risks). Linked to the EQOs are various Action Programmes including measures such as financial, research and development, and training and extension services. For example the key measures to reduce nutrient leaching under the *Action Programme for Reducing Plant Nutrient Losses from Agriculture* [15] are: regulations on the area of winter crop cover; storage of manure; covering and filling of slurry stores; limits on manure and organic fertilisers (based on phosphorus content); limits on nitrogen application, and on the handling and timing of manure and

fertiliser application; environmental support under the ERDP for catch crops and spring tillage, bufferzones and wetlands; taxes on nitrogen and cadmium; extension services and information campaigns, including *Focus on nutrients* [16]; and research and development.

National taxation policies also impact on agriculture. To encourage sustainable farming practices and reduce environmental risks, fertilisers, pesticides and cadmium in fertilisers have been taxed since 1984 [2]. These taxes are based on product composition, with about three-quarters of the revenue used to fund measures to reduce pollution and the remainder for research, development, training and extension [17]. The taxes in 2002 on fertilisers amounted to SEK 305 (EUR 33) million and on pesticides SEK 43 (EUR 4) million. On cadmium the taxes amounted to SEK 10 (EUR 1) million over 2000 to 2005 [2, 16]. Farmers are reimbursed up to 100% of the energy tax on fuel, 100% for electricity (from 2004, 98%) and up to nearly 80% of the carbon dioxide duty (climate change levy) on fuel used for heating and stationary engines, while greenhouse horticulture can purchase fuel at a reduced rate [2, 17, 18]. Biofuels are exempt from carbon dioxide and energy taxes from 2004 to 2008 [18, 19].

International environmental agreements important to agriculture include: those seeking to curb nutrient emissions into the Baltic Sea (*HELCOM Convention*) and the North Sea and Atlantic (*OSPAR Convention*); the *Gothenburg Protocol* concerning ammonia emissions [15]; greenhouse gases (*Kyoto Protocol*); and commitments under the *Convention of Biological Diversity* [8].

3.26.2. Environmental performance of agriculture

Biodiversity and landscape conservation and reducing water and air pollution are the key national environmental quality objectives (EQOs) for agriculture. The ERDP is a major tool for reaching the EQOs related to agriculture. Under the EQOs some interim targets to 2010 have been established to guide programmes and initiatives compared to a baseline for the year 2000 [2]. Sometimes there are no specific interim targets in the EQOs. However, the ERDP often includes quantitative targets that are based on the EQOs in addition to other targets such as the proportion of organic farming. The EQO targets for agricultural biodiversity and landscape conservation include preservation of all pasture and more specifically an increase of: the area of traditionally managed meadow land by at least 5 000 hectares (ha); endangered pasture by 13 000 ha; the number of landscape features (*e.g.* ponds, ditches, hedges) which should increase by 70%; and the restoration/establishment of 12 000 ha of wetlands. Within the ERDP targets by 2006 are for sustainable farming practices to be applied to 450 000 ha of semi-natural pasture and meadows, and 600 000 ha of ley farming maintained to create a varied landscape in woodland areas

EQOs interim targets for reducing water and air pollution are that by 2010 compared to 1995 levels there should be: a continuous reduction of pesticide risks; a 30% reduction of nitrogen emissions into marine waters; a 20% reduction of waterborne losses of phosphorus compounds from human activities; and a 15% reduction in ammonia emissions. There has been no specification of agriculture´s share in these nutrient targets. Agricultural water pollution is addressed within the ERDP by planning to increase by 2006: riparian bufferzones to 5 500 ha; EQO catch crops and spring tillage to 50 000 ha and wetlands to 6 000 ha. For ***organic farming*** the objective by the Parliament was to increase the area to 20% of total arable land by 2005 and for 10% of dairy cows, slaughtered cattle and lambs to be organically produced. New targets were established in 2006 to expand certified organic farming by 2010 to 20% of the total agriculture land area and sharply increase production of certified milk, egg, beef, pork and poultry meat.

There are no severe problems with soil erosion or deterioration in soil quality, except in some very limited areas. Soil erosion by water is a marginal issue around Lake Siljan and northern river valleys, and wind erosion may occur in limited parts of south and southwestern Sweden [10, 20, 21]. There is, however, concern with soil compaction, estimated to bring about harvest losses of 5-10% [21], although some research suggests a low risk of subsoil compaction in soils [22].

Pressure from agricultural water pollutants has been reduced since 1990, but is as yet insufficient to meet domestic and international commitments to combat water pollution [2, 23, 24]. Despite the contraction of the farm sector over the past 15 years it remains the main anthropogenic source of nutrient discharge into water [25], partly because of the more rapid reduction in nutrient discharges from other sources. For example about 95% of municipal and industrial waste water treatment plants remove nutrients from their effluent [2, 26]. Concerning pesticides, while concentrations in streams remain low, they are harmful to some aquatic habitats in areas that are intensively farmed [2].

The reduction in agricultural nutrient surpluses (input minus output of nutrients; nitrogen and phosphorus) over the period 1990-92 to 2002-04 was most marked (in absolute terms) for phosphorus (–67%) compared to nitrogen (–21%), with surpluses per hectare of agricultural land considerably lower than the EU15 and OECD average levels (Figure 3.26.2). Much of the reduction in surpluses has been a result of: a decrease in inorganic fertiliser use, especially phosphorus relative to nitrogen; lower use of sewage sludge [27]; and reduced animal numbers (*i.e.* less manure). At the same time the uptake of nutrients by crops and pasture showed only a small decrease. As a result of these changes there has been a marked improvement in P use efficiency (*i.e.* ratio of P output to P input), with Sweden now having one of the highest levels of P use efficiency across OECD countries with also, but to a lesser extent, an improvement in N use efficiency. Even so, the amount of P stored in arable soils has not diminished [2], as many soils have accumulated phosphorus [26, 28], although there are considerable uncertainties about the transport of P through soils into water [23].

Nitrogen loading from arable land declined by over 7 000 tonnes between 1995 and 2003. This was largely due to: a reduction in the arable area; improved N efficiency; ERDP measures, such as the use of catch crops, the delay of tillage until spring, and legislative measures, for example, manure spreading in spring instead of autumn [12, 15, 29]. About 60% of farmland was under a nutrient management plan (NMP) in the period 2002-04, while in 2000/01 about 90% of dairy and pig farms had storage capacity for manure of more than 7 months [30]. NMPs are included in voluntary environmental schemes as Integrated Production schemes or among farmers taking part in the campaign *Focus on Nutrients* [16]. The nitrogen and cadmium fertiliser taxes have had a modest impact in lowering nitrogen fertiliser use [2, 24], although without the tax it is estimated that nitrogen fertiliser use would have been 10% higher [23].

Despite lower nitrogen loading and farm nutrient surpluses it is difficult to discern a reduction in water pollution, although there are some reports of improvement [12, 27, 31]. By 2000 excess agricultural nitrogen and phosphorus accounted for almost 50% and 25% respectively of anthropogenic pollution in surface waters, and about 49% and 46 % for N and P in coastal waters (*i.e.* the West Sea, the Baltic and the Gulf of Bothnia) [1, 26]. In 2000 none of the monitoring points in watersheds had nitrates in excess of drinking water

standards for surface and groundwater. In certain monitoring points within sensitive areas nitrate levels above 50 mg/l have been measured, but overall the levels of nitrate in groundwater declined for a number of monitoring points between 1996 to 2002. Retention of nitrates in groundwater is probably low because of the drainage systems used on most arable land and the underlying geology [29]. Also more than 6% of lakes in agricultural areas exceeded the environmental threshold value for eutrophication [2, 10], especially in intensively farmed areas [32]. Moreover, losses of nutrients from the root zones in arable areas declined between 1995 and 2003 (Figure 3.26.3). Between 1995 and 2000 agricultural N and P discharges into the Baltic declined by 13% and 19% respectively, compared to respective figures of 25% and 11% from other sources [2]. The sharp reduction in sewage sludge used on farmland, from around 100 000 to 20 000 tonnes from 1987 to 2003, plus lowering the cadmium content in phosphorus fertilisers, has led to a substantial reduction in cadmium inputs to water [1, 2].

There has been a reduction in farm use of pesticides and associated environmental risks, during the period from 1990 to 2004 [12, 33]. The reduction in pesticide use (active ingredients) of 3% between 1990-92 and 2001-03 was close to the EU15 and OECD averages over this period (Figure 3.26.2). While overall pesticide use has declined since 1990, from the mid-1990s to 2004 there was a slight increase, although the intensity of use per hectare remained largely unchanged [1, 34]. The rise in pesticide use was mainly due to the growing use of herbicides (glyphosate) with the reduction in tillage and greater green cover over winter to help reduce nitrogen leaching and soil erosion [2]. However, the sharp rise in pesticide sales in 2003 resulted from stockpiling in anticipation of an increase in the pesticide tax by 50% at the beginning of 2004. Subsequently there was a large drop in pesticide sales in 2004, before it returned to trend levels in 2005 [34].

The Swedish National Chemicals Inspectorate pesticide risk indicators estimate a marked decrease in environmental risk (terrestrial and aquatic ecotoxicity) of 35% between 1988 to 2004, and an even larger reduction of 70% for farm operator health risks [13, 33]. The main reasons for the reduction in pesticide risk have been associated with: targeted information and advisory efforts; regulation of some problematic pesticides; improved product development; the impact of the pesticide tax [24, 33]; the obligation for all farm workers to undergo training to become certified pesticide users [2]; and an increase in the area farmed on which pesticides are not applied, including organic farms [10].

Systematic national monitoring of pesticides in water began in 2002 and only limited results are available. However, since 1992 data have been collected for Vemmenhög in southern Sweden, where pesticide concentration in surface water declined by over 90% by 2004 [10, 35]. However, pesticide levels high enough to cause concern have been reported for 9% of municipal wells (*e.g.* Gotland, Uppsala). However, concentrations of some persistent pesticide pollutants (*e.g.* DDT) in fish and other aquatic species continued to fall over the 1990s, although DDT has been banned in Sweden since the 1970s [2].

Ammonia emissions from agriculture declined between 1995 and 2001-03 at a greater rate than the EU15 and OECD averages (Figure 3.26.2). Farming accounts for 84% (2001-03) of ammonia emissions, with over 90% of emissions coming from livestock manure and the remainder from fertiliser use [1]. Between 1995 and 2001-03 around half the reduction in ammonia emissions resulted from improved manure management, with the rest mainly due to lower pig and dairy cow numbers [2]. Sweden achieved the 2010 target for total ammonia emissions under the *Gothenburg Protocol* by 2001-03, but requires a further cut

of 2% to meet the national EQO 2010 target [12]. The reduction of agricultural ammonia emissions has contributed to an overall decline in acidifying pollutants, easing pressure on ecosystems sensitive to excess acidity [12].

Agricultural greenhouse gas (GHG) emissions declined, by 6% compared to over 3% from all sources across the country over the period 1990-92 to 2002-04. Under the EU *Burden Sharing Agreement* to meet the *Kyoto Protocol* commitment allows Sweden to increase GHG emissions by 4% up to 2008-12 compared to 1990 levels [19]. Farming now contributes around 12% of total GHG emissions, due to emissions of methane and nitrous oxide [19]. The main reasons for the steady decline in agricultural GHGs are linked to lower livestock numbers, reduced use of fertilisers and a decrease in spreading livestock manure [19]. Projections indicate a further reduction in agricultural GHGs up to 2010, which is likely to be influenced by the reforms of the EU CAP leading to an expected reduction in livestock numbers up to 2010 [19]. ***Carbon sequestration in agricultural soils*** has the potential to reduce GHG emissions, and while most agricultural soils are close to a steady state in terms of soil organic carbon, about 10% of arable soils are estimated to lose around 1 million tonnes of carbon (or 3.8 million tonnes of CO_2) annually [36].

Direct on-farm energy consumption decreased by 15% compared to an increase of 10% across the economy over the period 1990-92 to 2002-04, with agriculture accounting for 2% of total energy consumption (2002-04) [37]. Sweden is one of the largest ethanol fuel producers in the EU, with grain as the main source of feedstock for ethanol production, although domestic production only provides about a quarter of total consumption. The use of biofuels in transport fuels has risen to 2% by 2004 (in terms of energy content), with the government target of 3% by 2005 [19]. According to the *Swedish Environmental Protection Agency*, cereal-based ethanol production is not the lowest-cost means of reducing GHG emissions compared with some other feedstocks [19].

The impact of agriculture development on biodiversity has been harmful in many ways, but there are some positive signs that the pressure could be easing [8]. Trends in the diversity of ***agricultural genetic resources***, despite limited information, suggest that many domestic crop varieties and livestock breeds have disappeared, but recently established conservation programmes are seeking to reverse the trend [12, 38]. National *ex situ* collections of plant (in the Nordic Gene Bank) and animal genetic material have been assembled, and there are also some regional collections [12, 38]. Most livestock breeds and some crop varieties used in production have increased in diversity, but declined for pulses, root crops and forage plants. While over 20 livestock breeds were endangered in 2002 and *in situ* conservation was being considered for their conservation [12], it is unclear whether they are included under conservation programmes to date [10].

About 20% of the wild species associated with agricultural landscapes are threatened with extinction [2, 8, 12]. More than half of the threatened species of mammals, birds and several groups of insects and almost 90% of threatened vascular plants are associated with agricultural landscapes [21]. For common farmland birds (*e.g.* Skylark – *Alauda arvensis*, Starling – *Sturnus vulgaris*, Yellow Hammer – *Emberiza citrinella*, and Curlew – *Numenius arquatus*), populations have been halved or more since 1975, with reductions continuing up to 2004, such that many farmland birds are endangered [12].

Loss of agricultural habitat, deterioration in habitat quality and changes in farming practices, are key reasons for the continued reduction in the abundance and richness of wild species populations associated with farming [7, 38]. The greatest variety of species

linked to farming are found in ***meadows and open or wooded pasture*** [8]. The area of semi-natural grassland, that is unfertilised meadows and pastures, has decreased substantially. Data between 1990-92 and 2002-04 show a decrease of 12 %. Due to different sources and definitions, the data are not fully comparable but from the mid-1990s when Sweden joined the EU the downward trend was reversed and the pasture area increased. The utilised area of pasture in 2005 was about half a million hectares. This was a result of the introduction of various forms of support, primarily livestock aid and agri-environmental payments to improve environmental management of pastures [2, 7, 12]. Wild species diversity has been reduced in meadows and pastures because of insufficient or discontinued grazing [7, 8]. Swedish research has shown that low-intensity grazing maintains a varied vegetation structure in semi-natural pasture which is highly favourable for maintaining some species (*e.g.* waders in coastal meadows, and certain vascular plant species) [39, 40, 41].

Small-scale habitats on farmland (e.g. field boundaries) are also declining [12], which is causing concern given their importance as a habitat for flora and fauna [42, 43, 44]. For ***wetlands***, however, agri-environmental payments are encouraging their restoration and creation on agricultural land, and between 2000 and 2005 the total area of wetlands restored and created grew from less than 500ha to over 4 500 ha [12].

There are signs that adverse impacts on culturally significant farmed landscapes are being halted, although progress varies regionally [2, 12]. This development is largely explained by the increasing number (or extent) of agricultural landscape features covered by agri-environmental schemes, by 2005 over 40% for point features (*e.g.* cairns, pollards) and almost 70% for linear features (*e.g.* hedges, stone walls) [12] (Figure 3.26.4). A survey of nearly 7000 farm buildings of cultural heritage value in 2003 showed that nearly 20% were derelict or in need of maintenance [13]. A programme introduced in 2005 is seeking to conserve farm buildings of heritage value by providing payments to farmers [12].

3.26.3. Overall agri-environmental performance

Overall agricultural pressure on the environment has diminished since 1990. The intensity of production has been reduced with environmental pressure largely decoupled from changes in farm production. The pressure on the environment has been lowered because of a growing trend towards the extensification of agriculture and measures used such as agri-environment schemes. Despite these improvements in agri-environmental performance, problems of water pollution from nutrients persist and farming remains the main source of nutrient pollution of water and ammonia emissions. Changes in farming structures and practices continue to harm biodiversity and culturally significant agricultural landscapes, although there are signs that these adverse impacts are being halted, especially for biodiversity as a result of the increasing area of semi-natural pastures under agri-environment schemes.

An increasing effort is being made to measure the environmental performance of agriculture. The Swedish Environmental Objectives Council annually updates some 100 environmental indicators, many linked to agriculture to track progress towards the national environmental quality objectives [12, 13, 14]. Further work is now underway to link these indicators with the system of national environmental accounts [2]. But detailed monitoring of biodiversity and cultural landscapes related to agriculture is an area requiring further improvement to help better evaluate recently introduced agri-environmental measures. Moreover, national monitoring of pesticides in water has only just begun [2, 7].

Progress by agriculture towards national environmental quality objective (EQO) targets has been variable [12]. It is unlikely that the EQO to reduce nutrient pollution of water and air (covering all sources of pollution, including agriculture) will be met by 2010. However, agricultural nitrogen and phosphorus surpluses (in tonnes) fell by about 20% and 70% respectively between 1995 and 2004. Nitrogen leaching from the root zone of arable land declined by some 7 000 tonnes between 1995 and 2003, which is close to the 2010 target for agriculture under the *Action Programme for Reducing Plant Nutrient Losses* (Figure 3.26.3). The EQO targets for N and P pollution of surface and coastal waters cannot easily be correlated with changes in nutrient surpluses [12, 29]. Progress has been made in lowering environmental and health risks associated with pesticide use. Sweden met the 2010 target for ammonia emissions under the *Gothenburg Protocol* by 2001-03, and only requires a cut of 2% to meet the EQO 2010 target to reduce emissions by 15% from 1995 levels. The *Swedish Environmental Objectives Council* consider that further reductions in ammonia and other acidifying emissions are necessary if critical loads for acidification are to be met [12].

For agricultural biodiversity and cultural agricultural landscape EQOs the situation is improving, but it is difficult to assess the quality of this improvement with any precision [12]. Areas of pasture, meadows and cultural features on arable land under agri-environmental schemes have all increased since around 2000 (Figure 3.26.4). At the present rate of progress in establishing and restoring ***wetlands*** it is likely that only 8 400 ha will have been restored/established by 2010, compared to the government EQO target of at least 12 000 ha [2, 12].

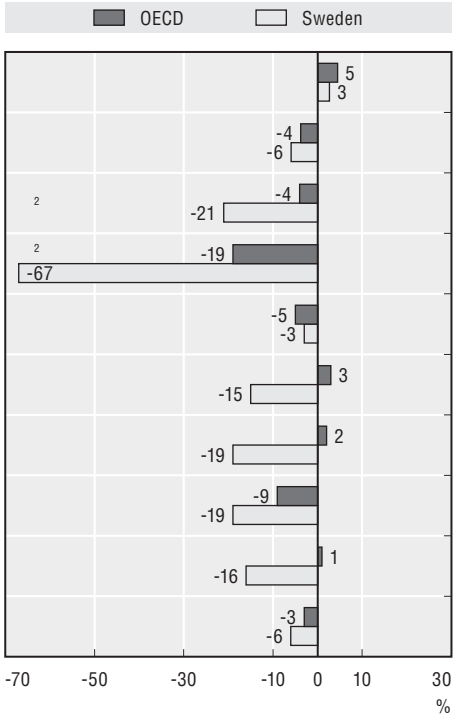
The EQO targets for organic farming have shown mixed results, with 19% of arable land under organic management by 2005 (compared to a target of 20%). The targets for organic beef and lamb production were met by 2005, but not for organic dairy. Even so, the number of certified organic farms has more than doubled between 1990 and 2004, while the area under certified organic farming rose from under 1% to around 6% of the total agricultural land area over the period 1993-95 to 2002-04 [1, 45].

Trends in the environmental performance of agriculture are encouraging but concerns remain. While about 90% of agricultural land is under some form of agri-environmental scheme [46], the projected structural changes in agriculture, especially the diminishing number of grazing livestock and continued loss of pasture to other uses in marginal areas [19], imply a potential further ***loss of semi-natural habitats***. This could have adverse impacts on flora and fauna [12, 47] and many threatened wild species may need specific action if they are not to become regionally extinct [38]. ***Energy and climate change taxes*** are used widely across the economy to meet environmental objectives, but farmers are provided a concession on these taxes which acts as a disincentive to further limit on-farm energy consumption, improve energy efficiency and reduce GHG emissions [2].

Taxes on fertilisers and pesticides have helped raise awareness among farmers of the environmental costs that use of these inputs entail, while also having an impact in reducing their use [2, 12]. Progress has been made in reducing agricultural nutrient surpluses but further effort will be required to meet the necessary EQOs and the Baltic Sea agreement *(HELCOM Convention)* to reduce eutrophication, especially for nitrogen, since much of the reduction in urban and industrial nitrogen pollution has already been achieved [2, 24]. For phosphorus (P) despite the large reduction in agricultural P surpluses, given the specific problems and uncertainty of the science related to P transport through the environment, more research and development and a long-term strategy will be required to reduce agricultural P pollution, especially with regard to contamination of the Baltic Sea [26].

Figure 3.26.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

Variable	Unit		Sweden	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	103	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–200	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	48	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	2	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–53	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–99	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–32	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	1.7	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–9	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–564	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

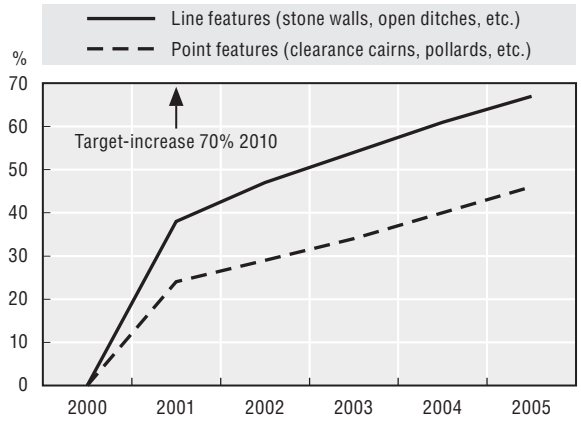
Figure 3.26.3. **Losses of nutrients from arable areas and the root zone**



1. Earlier model calculation, Environment Protection Agency (EPA), Report 4735, 1997; Report 5248, 2002.
2. Modified model calculation from H. Johnson and K. Martensson, EPA Report 5248.

Figure 3.26.4. **Cultural features on arable land**

Percentage change in number or extent of landscape features covered by agri-environment scheme



Source: Environmental Objectives Portal.

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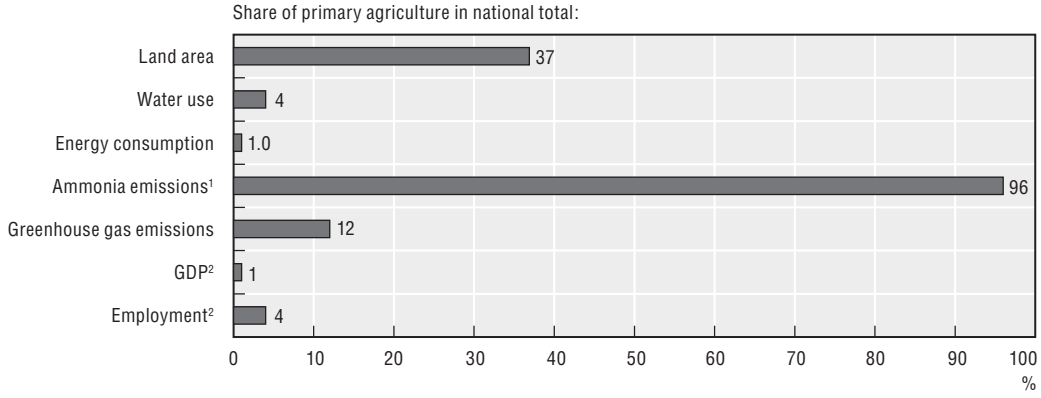
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3.27. SWITZERLAND

Figure 3.27.1. **National agri-environmental and economic profile, 2002-04: Switzerland**



StatLink http://dx.doi.org/10.1787/301143871707

1. Data refer to the period 2000-02.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.27.1. Agricultural sector trends and policy context

Agriculture is a small and contracting sector in the economy, with its contribution to GDP and employment at about 1% and 4% respectively [1, 2] (Figure 3.27.1). Both the volume and value of agricultural production decreased over the period 1990-92 to 2002-04, by around 4% and 30% respectively [3]. Farm labour productivity rose by 1.4% per annum between 1990 and 2004 [3].

The intensity of agricultural production is diminishing, with farm input use falling more sharply than the reduction in the volume of agricultural production (over 4%) and the area farmed (–3%) over the period 1990-92 to 2002-04 (Figure 3.27.2). As a result, agricultural production has become more extensive. From 1990-92 to 2002-04 inorganic fertiliser use fell by over 20% for nitrogen fertiliser and 60% for phosphate fertiliser, pesticide use fell by almost 30%, and direct on-farm energy consumption by nearly 30% (Figure 3.27.2). Farmland accounts for about 37% of the total land area, of which around 25% is arable and permanent cropland, and much of the rest permanent pasture (2002-04). About 60% is summer (mountain) pasture on altitudes up to 3 000 m [3]. With climate and topography favouring grazing, animal production (mainly cattle) account for nearly 70% of the value of final farm output [4].

Agricultural support has declined, but is still more than twice the OECD average. Support to farmers (as measured by the OECD's Producer Support Estimate) declined from 78% of farm receipts in 1986-88 to 71% in 2002-04, compared to the OECD average of 31% [5]. The share of output and input linked support, which provides the greatest incentive to expand

production, fell from 92% of the PSE in 1986-88 to 66% in 2002-04. Over the same period total support to agriculture, including border protection, fell from about CHF 10 to 8 (USD 7 to 6) billion per annum, declining as a share of GDP from 4% to just under 2% [5].

There has been growing emphasis on agri-environmental policies [6]. From 1993 *Ecological Direct Payments* were granted on condition that farmers adopt a set of environmental management practices. By 2004 these payments were 6% of the PSE [5], and 15% of budgetary expenditure on agriculture [3]. About 40% of these payments were provided to improve animal welfare; and over 30% were used to finance *ecological compensation areas* (ECAs) to develop more extensive farming and semi-natural habitats (*e.g.* extensive meadows, hedges, floral and rotation fallow, extensive cereal and rapeseed production) (Figure 3.27.3). A further 20% was assigned for summer pasturing to help prevent scrub growth; and much of the remaining 10% went to organic farming [5]. Revision of the *Agricultural Policy Reform* programme, which provided the basic framework governing agricultural policy for the 1999-03 period, required that any general direct payment to farmers meet five environmental criteria going beyond legal environmental requirements: a balanced use of nutrients; at least 7% of the farm area to be under extensive practices or semi-natural habitats (ECAs); crop rotation; soil protection; and improved pesticide management [6]. Animal welfare is an additional sixth criterion.

Farming is subject to economy wide environmental measures and international environmental agreements. The *Water Protection Act* requires farmers to limit manure and fertiliser application per hectare; install facilities to store manure for at least three months; and adopt practices to prevent pollution of water from fertilisers and pesticides [4]. Under the *Order on Hazardous Substances* soil nutrient assessment is compulsory for each crop during the growing season [7]. Farming is affected by various international environmental agreements, including lowering ammonia emissions (*Gothenburg Protocol*) and greenhouse gas emissions (*Kyoto Protocol*).

3.27.2. Environmental performance of agriculture

Agriculture plays a key role in the national sustainable development strategy. The main environmental challenges facing agriculture were identified in 2002 by the Federal government which established a number of intermediate agri-environmental targets for 2005 (from a 1990-92 base), including: reducing surplus nitrogen (23%) and phosphorus (50%); lowering pesticide use (30%) and ammonia emissions (9%); achieving 10% of farmland as *ecological compensation areas*; cultivating 98% of farmland according to ecological compliance or organic farming standards; and requiring 90% of drinking water in agricultural areas to have a nitrate level below 40 mg/l [6, 8, 9, 10].

Soil quality is not a national concern but is important in some regions. Data on ***soil erosion*** are poor as there is no national monitoring network nor database on soil erosion [11]. On arable land, average soil losses are less than 1 tonne per hectare annually [11], although in some regions, such as the Central Lowlands, 10%-40% of arable land is at risk of erosion [4]. Soil erosion risks are being minimised with the high and increasing area of farmland under soil conservation management practices (*e.g.* conservation tillage, crop rotations) and permanent cover throughout the year. Over 95% of farmland conformed with these practices in 2002-04. Heavy rain is the primary cause of erosion in most areas at high risk [4]. ***Soil compaction*** due to farm machinery is a concern but no data exist on the extent of the problem [4].

Soil organic carbon (SOC) stocks have been lost from peatland cultivation and conversion of farmland to urbanisation and forestation. But farmed soils may be near their limit with respect to SOC storage, because of the extensification of farming and over 70% of farmland being under permanent pasture [12, 13]. Research suggests that soil biodiversity activity (*e.g.* beetles, spiders, earthworms) is higher in the areas under organic rather than "conventional" management practices [4]. Heavy metals in farm soils, mainly from air emissions but also from fertilisers, sewage sludge and manure, have an impact on soil fertility. Exceedence of federal heavy metals standards is widespread across all agricultural land, with between 5% and 10% of monitoring sites for lead, copper, cadmium and zinc exceeding the standards [14]. While sewage sludge spread on agricultural land has been a major source of heavy metals, its use has been prohibited since 2006, with a transition period until 2008 [7].

Some progress has been achieved in reducing the pressure from agriculture on water quality. Water quality has improved both in certain surface waters affected by urban pollution and in agricultural regions. However, the situation in some regions is still a matter of concern [7, 10]. The main water pollutants derived from agriculture include nutrients and pesticides.

Agricultural nutrient surpluses have decreased by 5% for nitrogen and 56% for phosphorus over the period 1990-92 to 2002-04 (Figure 3.27.2) [9]. However, the intensity of nutrient surpluses (expressed per hectare of farmland) is close to the OECD and EU15 averages for nitrogen, but considerably lower than these averages for phosphorus (Figure 3.27.2). Much of the reduction in nutrient surpluses is explained by lower fertiliser use, especially inorganic fertiliser, significantly so in the case of phosphate fertiliser and, to some extent, greater use of livestock feeds containing less phosphorus [15], especially as overall livestock numbers (hence manure output) and crop uptake of nutrients showed only a small reduction over this period [3]. However, most of the reduction in nitrogen surpluses occurred during the period 1990-97, and since then surpluses have increased, largely explained by a rise in fertiliser use, lower crop output (resulting in reduced nitrogen uptake) and the prohibition of the use of animal meal in livestock feeding. The efficiency of nutrient use improved over the period 1990 to 2002, markedly so far phosphorus reflecting the fall in inorganic phosphorus fertiliser use while the volume of crop production decreased by 13% (Figure 3.27.4). Moreover, most farms and farmland were under a nutrient management plan, with around 90% of farms (2000-03) conducting soil nutrient tests [3]. In addition, manure storage capacity rose by over 50% from 1990 to 2003 [16].

Despite reductions in nutrient surpluses, agricultural nutrient pollution of water persists, mainly in arable farming regions [4, 6, 9]. Farming contributes around 40% of nitrates and over 20% of phosphorus in surface water. With respect to nitrates in groundwater, agriculture's share is 75% [4]. The concentrations of nitrates in groundwater in monitoring points in agricultural areas have declined from around 20 mg/l in the mid-1990s to 18 mg/l by 2003. Over 10% of monitoring points (risk areas) in arable cropping areas have nitrate concentrations greater than 40 mg/l [14, 17]. About 3% of monitoring points in agricultural areas exceed drinking water standards, although this share is low compared to many other OECD countries [17]. Pollution from phosphorus is also evident in some lakes. For certain lakes (*e.g.* Lakes Hallwil and Baldegg) [3], agriculture is a key source of phosphorus pollution of surface water. This follows the ban on phosphate use in detergents enforced in 1986 [4].

Pressure on water quality from agricultural pesticides has eased. Pesticide sale quantities (active ingredients) decreased by 28% between 1990-92 and 2001-03, but the change in sales stabilised from 1998 to 2004 (Figure 3.27.2) [3]. In part, the reduction in pesticide use is explained by the expansion in the area of arable and permanent crops under integrated pesticide management practices rising to over 95% by 2000-03, and the increase in organic farming. Switzerland now has the highest share of agricultural land under ***organic farming*** in the OECD at over 10% (2002-04) compared to 2% in 1993-95. The reduction in pesticide use can also be partly explained by the technical progress of the pesticide industry in replacing high with more low dosage products that are more targeted. About 65% of groundwater monitoring sites in agricultural areas showed the presence of one or more pesticides in 2002, with atrazine especially prominent [4, 17]. In arable farming regions, under 15% of groundwater monitoring sites (2002) had pesticide concentrations in excess of drinking water standards. ***Methyl bromide*** (an ozone depleting pesticide) use by primary agriculture was eliminated in the late 1980s, but small quantities are still used by the agro-food industry [18].

Farming's use of water resources is small in a largely rain-fed agriculture. Farming accounts for around 4% of total annual water abstractions, given that only 2% of the total agricultural land is irrigated. Farmers are required to pay for wastewater treatment as well as for water supply, a situation which does not apply in most other OECD countries [19].

Ammonia emissions from agriculture fell by 12% over the period 1990-92 to 2000-02, according to recent modelled results (Figure 3.27.2). Farming's share of total ammonia emissions is 96%. Much of the decrease in ammonia emissions, which vary regionally, has resulted from improvements in livestock manure and fertiliser management [20]. Ammonia emissions contribute 60-80% of the nitrogen input to sensitive ecosystems (*e.g.* forests, raised bogs, species rich grasslands). Critical loads of nitrogen (the risk indicator for eutrophication) were exceeded at 95% of forest sites and 55% of other semi-natural ecosystem sites around 2000 [20]. With the substantial reduction of sulphur and nitrous oxide emissions, nitrogen compounds from ammonia now contribute about 50% of the acidifying air pollution of ecosystems [20, 21]. An integrated assessment of acidifying emissions has shown that agricultural ammonia emissions should be further reduced by around 50% in order not to exceed critical loads that can damage ecosystems [20, 22]. Under the *Gothenburg Protocol* Switzerland agreed to reduce total ammonia emissions to 63 000 tonnes by 2010, but by 2000-02 Switzerland had already met this target, with emissions down to 59 333 tonnes.

Agricultural emissions of greenhouse gases (GHGs) have decreased, and at a more rapid rate than other sectors of the economy. Agricultural GHGs, which contributed 12% of national GHGs (2002-04), declined by 7% between 1990-92 and 2002-04 (Figure 3.27.2). This compares to a 3% reduction in total emissions over the same period and the country's total reduction commitment of –8% under the *Kyoto Protocol* by 2008-12 [23]. There are no direct policies that target GHG reductions in agriculture, but the decrease is partly the indirect consequence of policies that have reduced livestock numbers and fertiliser use [24, 25]. Agricultural methane and nitrous oxide GHG emissions declined. Agricultural ***direct on-farm energy consumption*** accounted for around 1% of total national energy consumption (2002-04), with the reduction in energy consumption between 1990 and 2004 (Figure 3.27.2), largely explained by the contraction of agricultural production and use of farm machinery. Agricultural energy efficiency (*i.e.* the ratio of direct and indirect farm energy consumption to food calories produced) remained virtually unchanged from 1990 to 2002 (Figure 3.27.4) [3]. The production of ***renewable energy*** from agricultural biomass and waste feedstocks to reduce GHG emissions is currently very low [26].

Reduced pressure from agriculture is helping to maintain biodiversity. With the reduction in farm chemical use and growth in *ecological compensation areas* (ECAs), pressure on biodiversity impacted by farming is easing. A high share of the nation's flora and fauna uses farmland as primary habitat, including mammals (75%) and invertebrates (55% butterflies, 40% of grasshoppers), although the share is lower for birds (22%). However, the share of endangered birds using farm habitat is 50%. In terms of ***agricultural genetic resources*** the diversity of crop varieties [27] and livestock breeds used in production has risen over the period 1990 to 2002 [3]. There are also programmes for conservation of crops and livestock *in situ* and extensive gene bank collections *ex situ*, while all endangered native livestock breeds are included under conservation programmes.

The area of agricultural semi-natural habitats under ECAs expanded from 2% to 11% of farmland (excluding summer pasture) from 1993 to 2004. Over 85% of the ECAs are extensive and low intensity managed meadows, and about 50% of ECAs are in lowland areas (60 000 ha) [3, 6]. There is no national monitoring of wild species on farmland, but some studies show mixed results for the impact of ECAs on flora and fauna [28, 29]. ECAs seem to have enhanced biodiversity (flora and fauna) in contrast to intensively managed farmland, although there are important variations between different ECA types [28, 29]. Species abundance and richness of meadow litter and hedgerow ECAs, however, seem to be higher than for hay meadow and traditional orchard ECAs, which still reflect the impact of intensive management practices [4, 29]. The ecological quality of mountainous ECAs was significantly higher than for lowland ECAs (Figure 3.27.3) [9, 10, 29].

Conversion of farmland to other uses has had adverse impacts on ecosystems and cultural landscapes. The fragmentation of agricultural land (by urban and transport development), the conversion of farmland to mainly urban use, and the abandonment of farmland in marginal areas have had an adverse impact on farmed ecosystems and ***cultural landscapes*** [4, 14]. For example, in some regions alpine pastures have been converted to forestry [4]. But there has been an increase in some linear landscape features on farmland, such as hedges and dry stone walls [4, 17]. ECAs are also reported to have reduced the effects of farm habitat fragmentation by serving to interconnect habitat sites [6]. A full national inventory of agricultural landscapes is not complete but work is underway to improve monitoring [4, 30]. The volume of agricultural ***water retaining capacity*** (*e.g.* small dams and ponds) grew by about 10% (1990-2002), which may have had beneficial consequences for biodiversity and flood control [17].

3.27.3. Overall agri-environmental performance

Overall the environmental pressures related to farming have decreased. The intensity of production has been reduced considerably, with environmental pressure largely decoupled from changes in farm production, and in some regions, because of a growing trend towards the extensification of agriculture. But despite these improvements in agri-environmental performance, progress has stagnated more recently. Farming remains the main single source of nutrient pollution of water and ammonia emissions; pesticide run-off from agricultural soil is a major water pollutant; and intensive farming practices continue to put pressure on biodiversity.

A considerable effort is underway to establish an agri-environmental monitoring system. In 2002 the Federal Office for Agriculture implemented the first stage of designing and implementing a set of agri-environmental indicators, with the indicators already established and being regularly reported by the government [3], and the full set planned to be operational in a first step by 2008 [31]. The Swiss Agency for the Environment has a

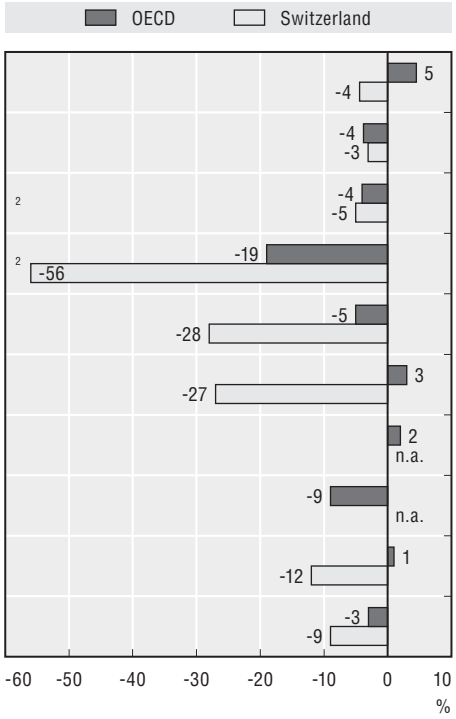
longer track record in overall environmental monitoring. It is constructing an *Eco-Fauna Database*, which is a matrix of the habitat and other requirements for nearly 3 000 species of fauna (*e.g.* mammals, butterflies, birds) [32], as well as monitoring networks for water, air and soil quality. These environmental monitoring programmes are also being integrated into agri-environmental policy evaluation [6]. However, there is an absence of national monitoring networks and databases for: agricultural soils; acidification; agricultural ecosystems and species diversity; farmed landscapes; while data on the pollution of water from phosphorus and pesticides are poor.

Areas under agri-environmental schemes have expanded and most of the government's intermediate environmental targets for agriculture have been met. Since the increase in expenditure on agri-environmental measures from the early 1990s, farmer participation in these schemes has grown to nearly 90% of all farms and 98% of farmland in 2003 [3]. Progress has been made in meeting some of the government's agri-environmental targets for 2005 (numbers in brackets) in relation to the early 1990s base, including ammonia emissions reduced by 18% (9%); groundwater nitrate levels in agricultural catchments lower than 40 mg/litre in 97% of the observation stations (90%); phosphorus surpluses reduced by 69% (50%); pesticide use falling by 31% (30%); the area under ECAs expanded to 11% of farmland (10%), with 97% of farmland under environmental compliance (98%); but the target will not be met for nitrogen surpluses which decreased by only 13% up to 2002-04 (23%) [3, 6]. (It should be noted that the changes indicated here do not precisely match those in the text above because of the use of different time periods, and indicator calculation methodologies in the case of nutrient balances.)

Despite better agri-environmental performance a number of key issues remain. As point source nutrient ***water pollution*** is now largely contained, the main issue is to control diffuse agricultural sources of pollution in some regions. But the canton's (local government) participation in government programmes targeting nitrates has been low [7], while the share of *Ecological Direct Payments* used to address water pollution is also low, less than 1% of total payments in 2003-04 [5]. The pollution of water from agricultural ***pesticide*** run-off and leaching persists. But the ban on sewage sludge will help to lower heavy metal contamination of soils. There has also been little improvement in agricultural ***energy efficiency*** although direct on-farm energy consumption decreased. ***Agricultural GHG*** emissions have been reduced over the past decade, but recent research suggests that further reductions in agriculture over the coming 10 years are likely to be limited [23]. While a considerable effort has been made to expand the areas under less intensive farming, the rate of progress in improving ***biodiversity*** quality has not been as significant [28, 29]. However, since 2001 payments have been provided to improve the quality of ECA habitats on condition that certain criteria are met, such as having at least 10 native tree or bush species per 10 metre length of hedgerows (Figure 3.27.3) [4, 33].

Figure 3.27.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

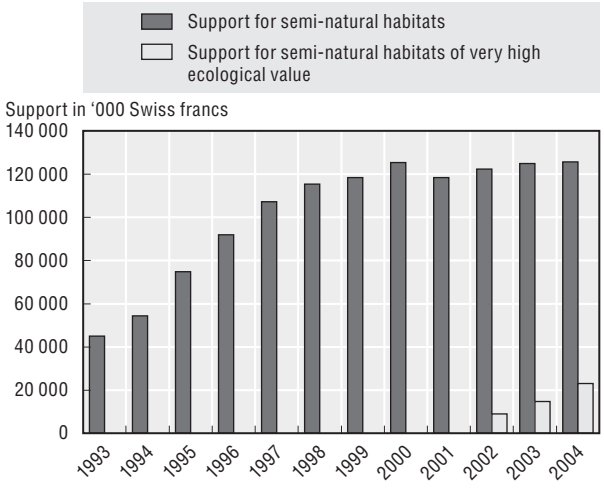
Variable	Unit		Switzerland	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	96	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–48	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	76	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	5	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–600	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–55	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	n.a.	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	n.a.	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–8	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–603	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

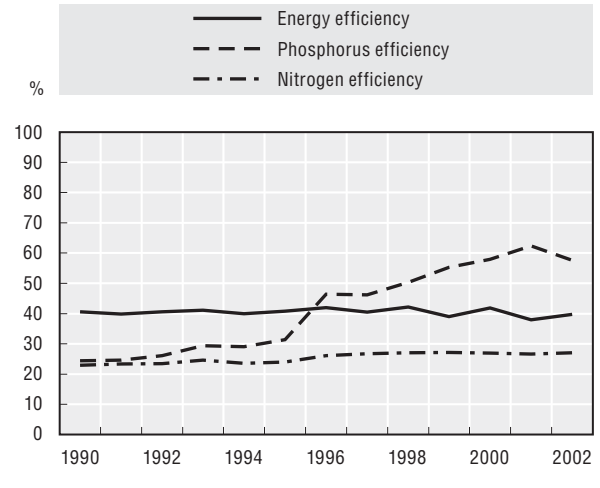
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.27.3. **Support for agricultural semi-natural habitats**



Source: Federal Office for Agriculture.

Figure 3.27.4. **Input/output efficiency of nitrogen, phosphorus and energy in agriculture**



Source: Swiss Confederation.

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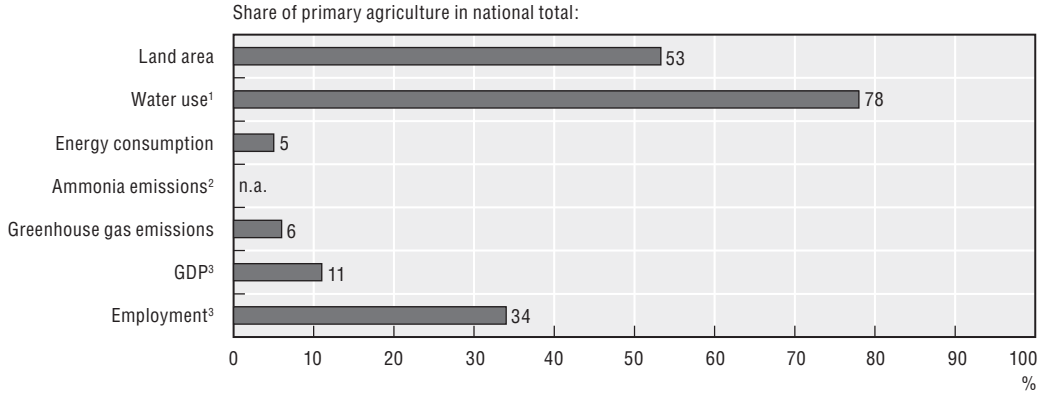
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3.28. TURKEY

Figure 3.28.1. **National agri-environmental and economic profile, 2002-04: Turkey**



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1. Data refer to the year 2001.
2. Data refer to the period 2001-03.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.28.1. Agricultural sector trends and policy context

Agriculture remains the major sector for employment in Turkey, but the sector's role in the economy is declining. Primary agriculture's share in employment decreased from 47% in 1990 to 34% in 2004, but the contribution to GDP is smaller declining over the same period from 17% to 11% [1, 2, 3] Figure 3.28.1. The agricultural labour force, about half of which are women who mainly work as unpaid family labour, experience a high incidence of poverty, poor education, and low provision of public services, although this situation is beginning to improve [2, 3].

Agricultural production has grown rapidly since 1990, among the highest rates of growth across OECD countries (Figures 3.28.2 and 3.28.3). Agriculture is becoming more intensive as the expansion in production and use of purchased variable inputs has grown more rapidly since 1990 than the 1% increase in area cultivated from 1990-92 to 2002-04 (Figures 3.28.2 and 3.28.3). The volume of agricultural production rose by 16% between 1990-92 and 2002-04, with crop production increasing by 19% and livestock 11% (mainly poultry, as grazing livestock numbers have fallen) [4]. Over the same period the use of purchased farm inputs also increased for inorganic nitrogen fertilisers by 11%, by 60% for pesticides (1993-2002), 59% for direct on-farm energy consumption, and by 65% for water use, although the use of inorganic phosphate fertilisers declined by –15% (Figures 3.28.2, 3.28.3 and 3.28.4). Arable farming dominates the agricultural sector, accounting for about 75% of output value, with the value share of fruit and vegetables over 40% [3].

Despite the growth in agricultural production subsistence and semi-subsistence farming is significant. The structure of farming largely remains small, family owned, highly fragmented, lacking capital, and using only basic technologies [2, 3, 5]. Rapid population growth, together with the prevailing inheritance laws, have led to farm fragmentation so that agricultural activities are predominantly of a low intensity, low productivity, subsistence-income type [2]. About 85% of farms (2003) are smaller than 9 hectares, although the remaining 15% of farms of over 10 hectares cultivate almost 60% of the total agricultural land area [2, 5, 6]. As a consequence of changes in farm structures agricultural productivity growth is well below that for other sectors in the economy [2, 3].

Support to agriculture has been highly variable since the mid-1980s but has remained below the OECD average. Support to farmers increased from an average of 16% of farm receipts in 1986-88 to 25% in 2002-04 (as measured by the OECD's Producer Support Estimate) compared to the OECD average of 30% [2, 6, 7]. Traditionally support to farmers was provided through market price support and input subsidies, which are the forms of support that most encourage production intensity and pressure on the environment. The *Agricultural Reform Implementation Project* (ARIP) over 2001-05, however, led to the reduction of these forms of support and their replacement with *Direct Income Support* (DIS) payments not linked to commodity production [3, 8]. Although about 80% of support to farmers was still provided through output-linked support in 2002-04, the share of input subsidies declined from 30% to 2%, while DIS payments represented 18% of support to farmers [7]. The share of total support to agriculture (budgetary plus market price support) in the GDP rose from 3.5% (1986-88) to a high of nearly 7% by 1999, but subsequently fell to around 4% by 2004-06 [2, 9].

Macroeconomic reforms from early 2000 onwards have had a major impact on the agricultural sector with important environmental implications. Following a period of macroeconomic instability over the 1990s (*e.g.* budget deficits, high inflation, volatile exchange rates) the government embarked on a path of disinflation requiring a reduction in government expenditure, including agriculture [2, 10]. This led to the introduction of ARIP in 2001, and later its extension, in time and scope, for the period 2005-07 [8, 9, 11]. From 1990 up to the introduction of ARIP support was provided for purchased farm inputs, including fertilisers, pesticides, irrigation water and energy, with a view to improving productivity [2, 12, 13]. However, subsidies on purchased fertilisers and pesticides (except for sugar beet) were largely abolished under the ARIP from 2001, although some infrastructure subsidies remain with the objective of improving farm production capacity, such as soil conservation, drainage, field levelling, and land consolidation [7, 9, 10]. The reduction in the fertiliser subsidy began in 1997, resulting in the lowering of the unit subsidy from 45% of the total price in 1997 to 15% by 2001 [6]. Support for use of diesel fuel is provided as budgetary expenditure rather than a tax concession, of TRY 23.9 (USD 18) per hectare (up to a maximum of 50 hectares in 2005 [9]. For some agricultural producers (*e.g.* poultry, greenhouses) support is given to lower energy costs at rates ranging from 20-50% of the cost of electricity provided to other consumers, while support is also provided to cover irrigation electricity costs [9, 14].

The development of agri-environmental policies has been limited since 1990, although recently more policy initiatives have been undertaken. As part of the amended (2005) ARIP, the *Environmentally Based Agricultural Land Protection* (CATAK) programme aims to protect environmentally fragile areas subject to severe erosion CATAK is initially implemented in four pilot provinces covering 5 000 hectares with annual transition payments (5 to 10 years) of TRY 560-1 260 (USD 400-900) per hectare [9, 11, 15]. Measures under CATAK include taking land

out of production ("set aside") and adoption of environmentally beneficial practices, such as contour tillage, pasture rehabilitation, and reduced flow irrigation [9, 15]. The *National Regulation on Organic Agriculture* (1994) defines the standards, definitions, certification and regulations covering organic farming, developed in harmony with the EU regulations, and up to 2006 there were no support payments for organic farming [16, 17, 18, 19]. The *Farmer Transition Program* (2001), which pays farmers for diverting from over-produced commodities to alternative commodities, provides an opportunity for the introduction of environmentally beneficial management practices, reinforced by the *Regulation of Good Agricultural Practices* (2004).

The costs of irrigation systems are being transferred from the government to local water user associations. With the progressive transfer of the operation and maintenance (O&M) of irrigation networks from the government General Directorate of State Hydraulic Works (DSI) and the now abolished General Directorate of Rural Services (GDRS) to self financing local water user associations, farmers are supporting a higher share of the costs of maintaining irrigation systems [2, 20]. The DSI is mainly responsible for the development and maintenance of large irrigation infrastructure (*e.g.* dams, drilling wells), while the now abolished GDRS largely developed small scale on-farm irrigation works [20]. Farmers partially cover O&M costs of irrigation water through annual crop and area based charges [3, 9]. While collection rates of water charges in publicly operated schemes are low and never exceed 54%, those in farmer operated schemes are almost 90% [7]. The DSI expenditure on irrigation O&M costs (net of farmer's fees) averaged TRY 103 (USD 75) million over 2004 and 2005 [9]. Currently farmers investing in drip irrigation are granted credit with 0% interest rate for a 5 year period or a 50% lump-sum of the costs of adopting this technology.

Some regional development projects have significant implications for agriculture and the environment. Many of these projects are financed by international development agencies and donors (*e.g.* the World Bank), as national funding is limited [3]. The World Bank supported *South-Eastern Anatolian Project* (GAP) (1983-2001) is the largest regional development project in Turkey covering 10% of the total land at an estimated cost of TRY 50 (USD 32) billion. GAP involves, among other objectives, to expand agricultural production in the region through building 22 dams and providing irrigation infrastructure for 1.7 million hectares of land by 2015 [3, 4, 13, 15, 21, 22, 23]. In the jointly EU and World Bank funded *Anatolian Watershed Rehabilitation Project* (AWRP), with funding of TRY 65 (USD 45) million over 2004 to 2012, the aim is to restore degraded soils to increase farm and forestry production [3, 11, 15].

Economy-wide environmental policies also affect agriculture. The *National Environmental Action Plan* (NEAP, 1998) provides for national and regional plans to generate information to combat land desertification and reduce discharges of nutrients, and a number of regulations control water and soil pollution, and protect biodiversity [9, 24]. Under the *National Action Programme for Combating Desertification*, strategies and information are developed to address problems of soil degradation, combat desertification, and evolve sustainable land use [24, 25]. The *Regulation on Water Pollution Control* (1988) defines water quality criteria according to the purpose for which the water is used, including treated waste water used for irrigation. A *Nitrate Directive* was adopted in February 2004, as part of the goal to harmonise with EU policies, but there is still the need to define the responsibilities of the organisations defined under the Directive [7].

Turkey also has commitments under various international environmental agreements, with implications for agriculture. An important driving force for the participation in these agreements has been linked to the goal of joining the EU [3]. As part its commitments under the *UN Convention to Combat Desertification,* the *National Action Programme for Combating Desertification* is addressing soil degradation issues (see above) [26]. Agriculture is also affected by Turkey's international commitment to limit emissions of methyl bromide (*Montreal Protocol*). The *National Biodiversity Strategy and Action Plan* (1998) seeks to meet commitments under the *Convention on Biological Diversity*. The Plan has provisions for: establishing protected areas, along with management plans; creation of wildlife sanctuaries; preservation of agricultural genetic resources; and levies a charge for grazing beyond common pastureland to reduce pressure on fragile ecosystems [3, 7, 24, 26]. With the signature to the *Ramsar Convention* to protect wetlands, the 2003-08 *National Wetlands Strategy Plan* sets general principles on the protection of wetlands, provides provisions for defining protected areas and preparing management plans, under the guidance of the National Wetland Commission [3, 26]. Turkey is also involved in addressing a number of environmental issues with neighbouring countries with implications for agriculture. This mainly concerns the diversion of water for irrigation, flood control and the pollution of trans-boundary rivers, and also pollution of the Mediterranean and Black Sea [13]. The transboundary rivers include the Meriç (Bulgaria and Greece), Arpaçay and Aras (Armenia, Azerbaijan and Iran), Çoruh (Georgia), Kura (Georgia, Azerbaijan, Armenia and Iran), Asi (Syria) and the Tigris and Euphrates (Syria and Iraq) [13, 23].

3.28.2. Environmental performance of agriculture

Overall agricultural pressure on the environment has risen since 1990, but the intensity of the farming system in terms of the use of purchased variable inputs, despite their rapid growth, is considerably lower than many other OECD countries [3, 13]. However, with the reduction in cattle, sheep and goat numbers relative to an increase in permanent pasture over the same period, this has eased pressure on land susceptible to erosion, but in some areas overgrazing remains a problem [27]. The key environmental concerns relate to: soil degradation, especially from erosion; overexploitation of water resources; water pollution, including salinisation from poor irrigation management practices; and adverse impacts of farming on biodiversity [3, 13, 27, 28].

Degradation of agricultural soils is a major and widespread environmental problem. One of the most acute forms of soil degradation is erosion, with 73% of total agricultural land and 68% of prime farmland prone to risk of erosion, mainly water erosion (71%) but also wind erosion (2%) [3, 24, 25]. Elevated rates of erosion have been induced, in particular, by: natural conditions, especially the climate and steep topography (over half the total land area is above 1 000 metres in elevation); unsuitable tillage and irrigation management practices; as well as overgrazing and stubble burning in some regions [3, 25, 27]. The eastern part of the country is less prone to erosion as pasture is dominant, however, overgrazing and other inappropriate pasture management practices have left about 60% of rangelands prone to erosion, especially in the Aegean and Marmara regions [3, 13, 25, 27]. Off-farm sediment flows have reduced the efficiency of dams through siltation and impacted adversely on aquatic ecosystems, despite abatement programmes initiated 25 years ago [3, 13, 25].

Other forms of soil degradation are more limited, with an estimated 6% of arable land suffering yield limitation due to salinisation and a further 12% affected by waterlogging [3, 25]. A study of the impact of salinisation and waterlogging on cotton production in the Menemen

region of the Gediz Delta, for example, revealed that yields were reduced by over 30% [29]. Inappropriate irrigation and fertiliser management practices, as well as excess extraction of water have been important causes of soil salinity in some areas [3, 25], with this problem growing rapidly in parts of the area under *South-Eastern Anatolian Project* (GAP) [30]. ***The uptake of soil conservation practices is poor***, with only around 4% of the area prone to risk of erosion subject to soil erosion prevention programmes, mainly caused by inadequate resources, technical skills and knowledge to address the problem [24, 25]. But the afforestation of some agricultural land has helped to combat erosion, especially since 1993 under the *National Tree Improvement Plan* [13, 30].

Overall pollution of water from agricultural activities is low compared to many other OECD countries, but in some regions the pressure on water quality from farming is high, especially certain irrigated areas [3, 13, 27]. But it is difficult to determine the extent and trends in water pollution due to agriculture, as monitoring data of agricultural pollution of rivers, lakes or marine waters is poor although the DSI does have a national network of monitoring sites [27]. Moreover, the trends in the main agricultural pollutants have diverged over the period 1990 to 2004. While there has been an almost continuous decline in the nutrient balance surpluses over this period (both nitrogen and phosphorus), at the same time pesticide use has increased.

There have been substantial reductions in agricultural nutrient surpluses, with a steady decline in both nitrogen (N) and phosphorus (P) surpluses (in tonnes) between 1990-92 to 2002-04, leaving aside occasional annual fluctuations (Figures 3.28.2 and 3.28.3). This largely reflects the reduction in livestock numbers except for poultry (less manure inputs), which has more than offset fluctuations in inorganic fertiliser use (see below) and the large rise in crop production (leading to higher nutrient uptake, hence, lower surpluses). The intensity of nutrient surpluses (expressed as kg N per ha) have been considerably lower than the EU15 and OECD averages, and by 2002-04 for nitrogen surpluses was about a third of the EU15 average and almost a half for phosphorus (Figure 3.28.2).

Trends in inorganic fertiliser use have fluctuated considerably since 1990 and influenced the overall development in nutrient surpluses. As agricultural support levels (including for fertilisers) rose over the period 1994 to 1999, fertiliser use also increased. During the policy reform period of 2000-02, however, when support for fertilisers was lowered, use fell substantially by around 25-30% (in volume terms), but recovered over 2003 and 2004 although remained below the peak of the late 1990s [2, 3, 10]. The application of inorganic fertilisers also appears to be below plant requirements, with an estimate for 2000 indicating that national nitrogen fertiliser use was 65% below soil requirements and 45% below requirements for phosphorus [3, 10]. Even so, while fertilisers are used in excess for some commercial farms, especially in the Marmara and Mediterranean regions, for smaller poorer holdings very little fertiliser is used in relation to soil requirements [10].

Agricultural pollution of water bodies from nutrients is in general low compared to other OECD countries since 1990, although in some localities pollution is a concern, especially the Aegean and Mediterranean regions [13, 27]. But drawing firm conclusions are difficult due to the lack of water monitoring stations in agricultural areas. Data over the period 1995 to 2005, however, estimates that 2.5% of monitoring sites in agricultural areas exceed recommended drinking water standards for nitrates in groundwater [31]. There is also some regional evidence of cadmium accumulation in soils where phosphorus application rates have been high, such as in tomato and sugar beet growing areas, which is of concern

for human health as cadmium can be taken up by plants [32]. There is no information on the adoption of nutrient management practices, including soil nutrient testing and development of manure storage facilities. It is likely, however, that uptake rates of these practices are low as many farmers have poor access to capital to invest in manure storage and other manure treatment technologies, and also have inadequate knowledge of nutrient management practices.

The growth in pesticide use has been among the most rapid across OECD countries, over the period 1993 to 2002 (volume of active ingredients) (Figures 3.28.2 and 3.28.3). The growth in pesticide use has been closely linked to the increase in crop production, in particular, horticultural production in the irrigated areas of the Marmara, Aegean and Mediterranean regions which account for over 70% of pesticide use [10, 25]. As with fertilisers, the trend in pesticide use grew rapidly from 1993 to 1997, declined over the policy reform period but has subsequently recovered [2, 3, 10]. To a limited extent the growth in ***organic farming*** has restricted the growth in pesticide use. But despite the rapid increase in organic farming since 1990 its share in total agricultural land area was the lowest in the OECD at under 0.5% in 2002-04, compared to the OECD average of nearly 2% and the EU15 average of almost 4%, although unlike many OECD countries no support is provided to organic producers [3, 16, 17, 18, 19]. Organic farming is largely geared toward export markets, mainly horticultural crops, but also cotton [16, 17, 18].

The overall intensity of pesticide use is low by comparison with other Mediterranean OECD countries, but there are concerns over adverse impacts on human health and the environment in some localities [3, 33]. A study of the Adana region estimated that nearly 13% of farmers reported ill-effects from pesticide use, while aerial spraying has raised concerns with pesticide drift [33, 34, 35]. It is unclear the extent to which integrated pesticide management practices are being used by farmers. There is no regular monitoring of pesticides in water bodies, but some studies report their presence in rivers, lakes, irrigation canals, and also on greenhouse vegetables [13, 34]. Some pesticides prohibited since the 1980s have also been detected (*e.g.* DDT, aldrin, dieldrin and other organochlorine pesticides), but below toxic levels for human health, although of some concern for their adverse impacts on aquatic ecosystems [36, 37, 38].

Agricultural water use grew by 65% between 1990-92 and 2001, among the highest rate of growth across OECD countries, and compares to the growth in water use for the economy as a whole of nearly 30% (Figures 3.28.2 and 3.28.4). As a result agriculture accounted for nearly 80% of water use by 2001. Much of the growth in water use is because of a 5% increase in the area irrigated from 1990-92 to 2001-03, with 9% of farmland under irrigation by 2001-03 (Figure 3.28.3). By 2005 nearly 5 million hectares were being irrigated, while over 8 million hectares are irrigable and up to 26 million hectares of land is suitable for irrigation (not taking economic considerations into account) which is about 60% of the total agricultural land area [2, 3, 15]. Most irrigation water is delivered by gravity flow and only 5% by pumping [39]. Larger farms tend to be irrigated from dams and reservoirs mainly subsidised by the government, with 1% of farmers using 15% of the irrigated land, while smaller farmers are more likely to irrigate from wells constructed at their own expense [40]. Recent government budget constraints have limited growth in the area irrigated, notably under the GAP [2].

With the rise in demand for water by the agricultural sector there is growing competition for water resources with other users and increasing environmental concerns. Much of the

water for irrigation is derived from reservoirs, but around 35% is pumped from groundwater. Many aquifers, however, are being exploited beyond their natural recharge rate, especially in the Mediterranean region, which is a concern as two-thirds of drinking water in the region is supplied from groundwater [3, 41]. The over extraction of groundwater in regions such as the Mediterranean is also a concern both because of the intrusion of sea water into aquifers, and also the growing competition for water resources with the tourism industry which, similarly to agriculture, has its peak demand period in the summer [13]. Some major irrigation projects have also been undertaken with little consideration of environmental management or impacts, with the loss of valuable ecosystems (*e.g.* steppe, wetlands) and increasing problems of salinity and agro-chemical run-off becoming widespread [3, 21, 27]. Even so, the GAP project is increasing the supply of domestically produced hydroelectricity and has brought socio-economic welfare gains to villagers [21, 41].

There has been a modest improvement in irrigation management practices. The use of the more efficient low pressure sprinklers and drip emitters technology has risen from a share of 4% to 8% of irrigation water, largely used on horticultural crops, but by 2000 nearly 92% of irrigation water was applied through the less efficient method of flooding [20, 31]. Despite the greater uptake by irrigators of more efficient water application technologies, partly induced by low interest credit for the purchase of drip irrigation technology, irrigation water application rates per hectare increased (*i.e.* a declining trend of irrigation water efficiency) by 56% between 1990-92 and 2001, compared to a decrease of –9% for the OECD on average. This might be explained not only by the high water losses from irrigation infrastructure (many canals are open so losses from evaporation are high), and lack of capital, but also by technical inefficiency in managing irrigation systems due to, for example, lack of technical knowledge and weak advisory services [1, 2, 11, 15, 27].

Low water charges have not been sufficient to cover irrigation infrastructure operation and maintenance (O&M) costs [2, 20]. It was estimated by the DSI in the late 1990s that water charges to cover O&M costs for gravity cotton irrigation systems should be 6 times above that actually paid by producers, and 31 times above the charge to producers to cover O&M plus fixed capital costs [42]. For irrigation systems requiring pumped water these differences would be appreciably greater [42]. But in recent years water charges have risen, as a result of the transfer of irrigated areas operated by the DSI to water user associations [39, 42]. A study of cotton and grape production in the Gediz Basin, for example, showed that where these transfers have occurred and water charges increased, irrigation water productivity showed significant gains [39].

Air pollution trends linked to farming have shown mixed results since 1990. Agricultural ***ammonia emissions*** probably increased between 1990 and 2004, but ammonia emission data are not regularly collected. The main sources of agricultural ammonia emissions are from nitrogen fertiliser use and livestock (manure and housing), which increased in the period since 1990. For ***methyl bromide*** use (an ozone depleting substance) Turkey along with most OECD countries has substantially reduced its use over the 1990s as agreed by the phase-out schedule under the *Montreal Protocol*, which seeks to reduce use by 20% in 2005 from the 1995-98 base period for Article 5 countries (*i.e.* developing countries), and complete phase out by 2015. Methyl bromide is largely used by the horticultural sector, especially as a soil fumigant [3, 34]. Turkey has exceeded this target with methyl bromide use reduced by 81% by 2004. The phase out of methyl bromide is being jointly planned and assisted by the UNEP, UNIDO and the World Bank [3].

Agricultural greenhouse gas (GHG) emissions declined by 21% between 1990-92 and 2002-04 (Figure 3.28.2). This compares to a 43% rise in economy wide GHG emissions and the reduction in EU15 agricultural GHG emissions of 7% [11]. Farming accounted for 6% of total national GHG emissions by 2002-04, but only 1% of total OECD agricultural GHG emissions. Agricultural emissions reductions are largely explained by the decrease in cattle, sheep and goat numbers, lowering methane emissions, partly offset by higher fertiliser use and crop production [11]. With the projected expansion of agricultural production up to 2016 and rising direct on-farm energy consumption, it can be expected that agricultural GHG emissions may rise [11].

Direct on-farm energy consumption rose by nearly 60% between 1990-92 to 2002-04, among the largest increase across OECD countries, contributing to agricultural GHG emissions (Figures 3.28.2 and 3.28.4) [43]. The growth in on-farm energy consumption was more rapid than for the national economy, 44% over the same period, although by 2002-04 agriculture accounted for only 5% of total energy consumption. Much of the rise in on-farm energy consumption is explained by the expansion in use and size of machinery, as a substitute for labour over the past 15 years, and greater demand for energy from pumping irrigation water [44]. While farm employment declined by around 13% between 1990-92 and 2001-03, the numbers of tractors and harvesters in use rose by 40% over the same period. The share of on-farm energy consumption from animal manure declined relative to an increase in use of diesel and electricity since 1990, part of a longer term trend [43]. Also the efficiency of agricultural energy use, as measured by the energy input-output ratio, has been declining since the mid-1970s as Turkish agriculture has become more energy intensive. A study of cotton production, however, has shown that energy efficiency could be improved [43, 45]. Projections indicate that agricultural energy consumption will continue to grow by nearly 5% annually (tons of oil equivalent) between 2003 and 2020 [11].

Renewable energy production from agricultural biomass feedstocks has been declining, from around 7% of total primary energy supply in 1990 to less than 5% by 2000 [14, 46, 47]. This is largely explained by the replacement of non-commercial fuel sources (*i.e.* mainly livestock manure) by commercial non-renewable energy sources, such as electricity and other fuels, with this trend projected to continue up to 2020 [46]. By the late 1990s almost 60% of livestock manure was burned for heating [48]. Numerous studies indicate, however, that there is considerable physical capacity to expand the use of agricultural biomass for renewable energy production, especially for heat and electricity generation and biogas, drawing on agricultural wastes, such as cereal straw and livestock waste [14, 47, 49, 50, 51]. There are no power plants in operation using biomass, and only two facilities producing biogas with a combined capacity of 5 Megawatts [46].

Carbon sequestration associated with agriculture has most likely increased since 1990, contributing to a reduction in GHG emissions. There are not, however, any national estimates of agricultural carbon sequestration although some regional studies have been completed [52]. The rise in carbon sequestration is most likely due to the 13% rise in permanent pasture area, decrease in area under arable crops, and to a lesser extent the conversion of farmland to use for forestry, although overall the total agricultural land area increased between 1990 and 2004. With improved management the potential of pasture to act as a GHG sink could be improved [11].

Turkey has a highly rich biodiversity which is under growing pressure from agriculture, although the impacts of farming on biodiversity are diverse, complex and poorly monitored [3, 11, 13]. The biological richness of Turkey is a consequence of a highly varied

biogeography, climate and different types of farming systems, with around three quarters of the European flora and fauna species found in the country [3, 13, 53]. But there is increasing pressure on biodiversity mainly due to: intensification in fertile areas with greater use of agro-chemicals; construction of large rural development projects altering the ecology of entire regions; and diversion of water for irrigation to the detriment of wetlands [3, 11, 13, 54]. At the same time there is the loss of some farmed habitats from the conversion to urban use, and in some marginal farming areas from the afforestation and abandonment of semi-natural farmed habitats to overgrowth, although overall the area of agricultural land increased since 1990 (Figures 3.28.2 and 3.28.3).

In terms of agricultural genetic resources Turkey has a role of global importance. The country is recognised as a "Vavilov" centre, which is an area where ***crops,*** such as Wheat (*Triticum spp.*), Barley (*Hordeum spp.*), Oats (*Avena spp.*), Peas (*Pisum sativum*) and Lentils (*Lens culinaris*) were first domesticated. Use of these crops have evolved over several thousand years providing progenitor species used in Mediterranean and temperate agricultural systems [53, 55, 56]. Under the *National Plant Genetic Resources Programme* 15 endangered species are under *in situ* conservation programmes (including wild relatives, for example, of wheat and lentils). *Ex situ* conservation involves a seed bank containing around 53 000 accessions and a vegetative gene bank having collected nearly 6 000 accessions, with these efforts supported through the World Bank and International Plant Genetic Resource Institute [31, 53, 56]. While high levels of plant genetic diversity exist *in situ*, both in the wild and in more marginal mountainous and semi-natural farming areas, substantial genetic erosion has occurred because of the abandonment of farming in these areas and where farming continues because of the introduction of high-yielding varieties [55, 57]. Moreover, there is insufficient resources, monitoring and institutional capacity to fully support *in situ* conservation across large areas, so informal approaches relying on farming communities are the primary form of plant conservation [26, 55, 56, 57]. For ***livestock breeds*** there was a reduction in the numbers of breeds used in marketed production between 1990 and 2000, especially for cattle, sheep and goats [31, 48]. There are *in situ* programmes for the conservation of local breeds, covering cattle, sheep, goats, poultry and other native breeds [31]. There is little information on *ex situ* collections or the conservation of endangered livestock breeds, although a study for sheep and goats indicates a number of breeds are at risk of extinction [58].

Agricultural land use and management practices are adversely impacting natural and semi-natural habitats, and as a consequence damaging wild flora and fauna species [3]. The 1% increase in the area under agriculture between 1990-92 to 2002-04 (Figures 3.28.2 and 3.28.3), has led to land clearing for farming, mainly involving the ploughing of steppe land and conversion of forests, coupled with intensification through greater use of agro-chemicals has had adverse impacts on wild species both direct and indirect [3, 53]. With the lowering of stocking densities on pasture, especially semi-natural grassland steppe areas, this has helped to ease the pressure on these habitats. Overgrazing, however, remains a problem in some regions, notably the grazing of forests and pasture near the Black Sea and in the Mediterranean where overgrazing has reduced the number of pastoral vegetation species during the 1990s from about 25 to 5-6 [13, 34].

Nationally there are some 200 wetlands, nine of which have been classified as sites of international importance under the Ramsar Convention, which Turkey signed in 1994 [3, 11]. Agriculture has been one of the major causes of ***wetland degradation***, including from the: adverse impacts of constructing irrigation projects and diversion of water causing changes

in water flows to wetlands; excessive extraction of aquifers reducing water flows to wetlands; agricultural pollutant run-off, especially the eutrophication of inland and coastal wetlands; and the expansion of the area cultivated in some areas leading to a loss of wetlands [3]. But the drainage of wetlands was largely halted in the mid-1990s, although some reclamation for agricultural use has continued, such as the Çukurova-Akyatan delta and Sultan marshes [11, 13, 27]. The impact of farming on bird populations measured by the BirdLife International ***Important Bird Areas*** (IBAs) indicator, defined as prime bird habitat, shows that around 40% of the most significant threats to Turkish IBAs originates from farming [41, 59]. The main threats include: intensification of production from greater use of agro-chemicals; loss of semi-natural farmed habitat to other uses; and construction of irrigation projects [3].

3.28.3. Overall agri-environmental performance

Overall the expansion in agricultural production has exerted greater pressure on the environment since 1990. This is in part because of the increased area farmed and greater use of purchased variable inputs including fertilisers (except phosphate fertiliser) pesticides, water and energy, although there has been a lowering of agricultural air pollution emissions (methyl bromide and greenhouse gases). Soil erosion remains a major problem and irrigation water application rates (litres per hectare) increased significantly, compared to a declining trend for most other OECD countries where irrigation is important. There are also concerns for biodiversity, both the erosion of agricultural genetic resources (notably plant species) and also harmful impacts of land use changes and farming practices on natural and semi-natural habitats and as a consequence harmful impacts on wild flora and fauna.

The agri-environmental monitoring system needs to be considerably improved, to help enhance the quality of information for policy makers to evaluate the environmental effectiveness of newly introduced agri-environmental and environmental policy measures [3, 27, 54]. Some areas of agri-environmental monitoring are now well established, especially related to irrigation water use and management, and greenhouse gas emissions. But for most agri-environmental issues monitoring is weak or, where data do exist, their quality and reliability are poor [3, 27]. Support from international groups, such as the World Bank, however, is helping to develop a base for tracking environmental performance.

Agri-environmental policies are being strengthened and many environmental measures have been introduced since the mid-1990s. Under the 2006 *Agricultural Policy Strategy 2006-10* the share of budgetary support for agri-environmental purposes will be 5% [15]. As part of the amended (2005) ARIP, the *Environmentally Based Agricultural Land Protection* (CATAK) programme, support will be provided for environmental cross compliance and organic farming, as well as combating soil erosion and developing irrigation systems that use less water [9]. The government is also in the process of introducing measures to encourage greater production and use of renewable energy, including energy and biofuels produced from agricultural biomass feedstocks [43]. These measures could be important in providing incentives for using the considerable potential of agricultural biomass as a feedstock for energy and fuel production that exists in Turkey [43]. Measures to address overgrazing, under the Grazing and Pasture Law of 1998, are attempting to restrict stocking levels on state owned grasslands [41].

Despite the introduction of policies to address agri-environmental issues many problems persist, although overall the intensity of agriculture is much lower than across most OECD

European countries. While in part soil degradation (particularly erosion) is naturally occurring, the absence of widespread adoption of soil conservation practices has failed to improve soil quality, in particular, as a result of overgrazing and ploughing grassland. Subsidies for purchased variable inputs while increasing farm output as intended, has kept agriculture on a technically suboptimal trend and led to unintended environmental damage [2, 13]. Continued subsidies for water charges and electricity for pumping (and diesel for machinery) are undermining the efforts to achieve sustainable agricultural water use, especially groundwater, and in the case of energy and diesel reduce greenhouse gas emissions. The operation and management responsibilities for local irrigation networks (previously run by a national monopoly), however, have been transferred to self-financing water user associations. This has led to an increase in water charges in order to cover operating costs and is helping toward more effective use of scarce water resources [2, 39, 42].

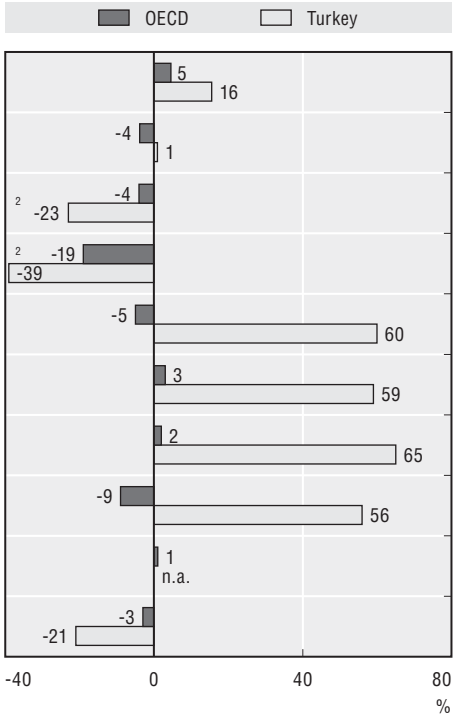
Projections suggest that agricultural production is likely to expand up to 2016, and that agricultural pressure on the environment may continue [60]. While most of the growth in production will derive from higher yields, the area cultivated for some crops may also increase, such as for cereals [60]. The future rise in agricultural production implies higher demand for water, with projections of water demand from other users (*e.g.* industry, households tourism) expected to be more rapid than for agriculture up to 2030, as national population, incomes and foreign tourism increase the demand for water [4, 42].

An important part of the government strategy toward expanding agricultural production are a number of large scale irrigation projects, in particular, the *South-Eastern Anatolian Project* (GAP). The GAP requires the utilisation of some of the water potential of the Dicle (Tigris) and Firat (Euphrates) to irrigate the 1.7 million hectares in the GAP region. This has raised concerns not only for the ecology of the GAP region, but also for water flows for neighbouring countries downstream, namely Iraq and Syria. At present there is some progress in addressing the environmental impacts of the GAP project and agreement between Turkey and these countries on the equitable allocation of water from the Dicle – Firat basin. These rivers comprise less than a half of Turkey's and most of Iraq's and Syria's water supply [23].

The agricultural sector is also undergoing structural changes with environmental implications. A key aspect to structural change in agriculture, which may impact on agri-environmental performance, is the extent to which small semi-subsistence farms can escape the vicious circle of low technical efficiency and technological and educational backwardness. Only 24% of the agricultural labour force had completed primary education (eight years) and 14% had completed secondary education or above by 2004 [1]. Improvements in human capital are clearly crucial to the future of Turkish farming and in raising agri-environmental performance. This needs to involve both increasing employment opportunities for farmers to leave the sector and improving the efficiency of those remaining in agriculture by upgrading the training and advisory services to assist farmers to adopt new, efficient and environmentally friendly farming practices. This may in turn help farmers address the key agri-environmental issues in Turkey by improving soil quality, increasing the efficiency of water use management, and conserving biodiversity.

Figure 3.28.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

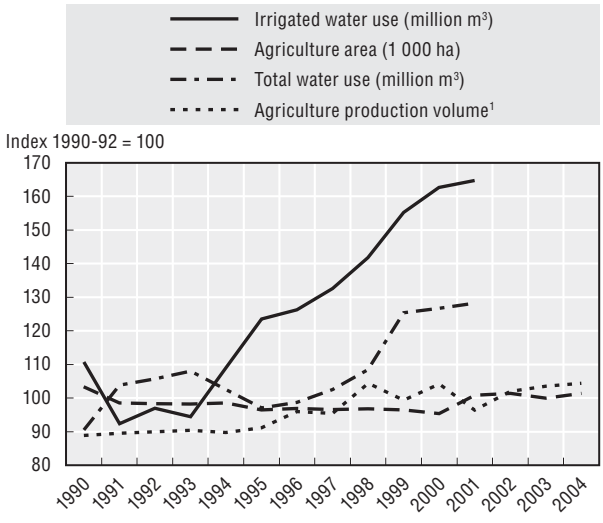
Variable	Unit		Turkey	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	116	105
Agricultural land area	000 hectares	1990-92 to 2002-04	352	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	28	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	5	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	+7 161	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+1 170	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+12 188	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	8.8	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	n.a.	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–3 930	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

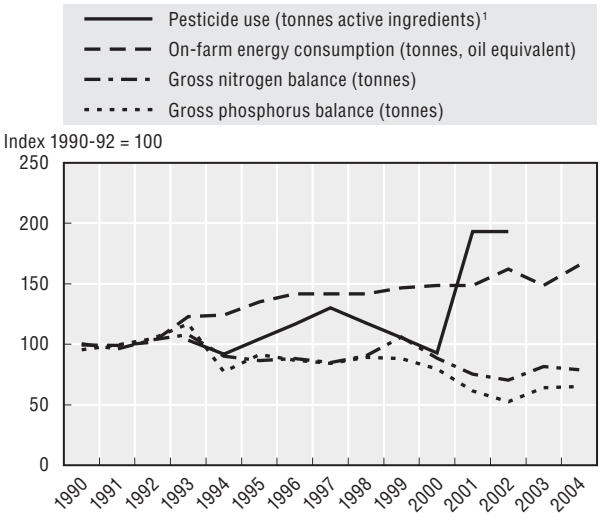
Figure 3.28.3. **Trends in key agri-environmental indicators**



1. Index 1999-2001 = 100.

Source: OECD Secretariat.

Figure 3.28.4. **Trends in key agri-environmental indicators**



1. Index 1993-95 = 100.

Source: OECD Secretariat.

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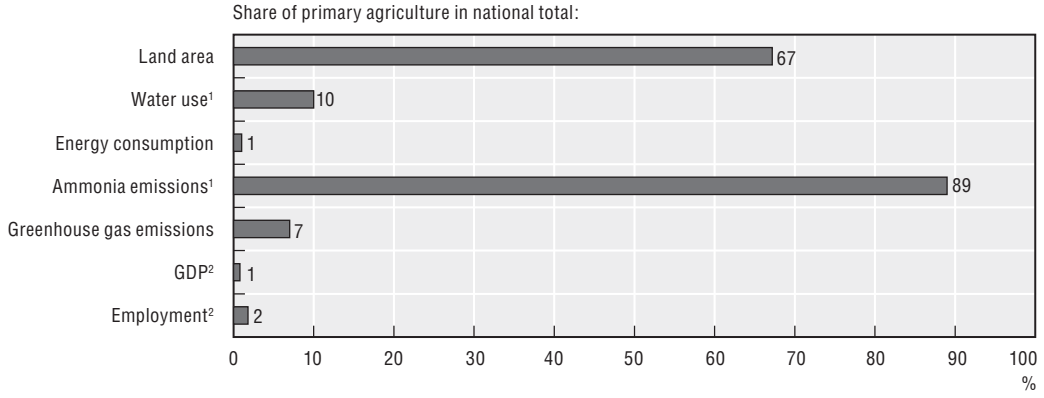
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3.29. UNITED KINGDOM

Figure 3.29.1. **National agri-environmental and economic profile, 2002-04: United Kingdom**



StatLink http://dx.doi.org/10.1787/301208146100

1. Data refer to the period 2001-03.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.29.1. Agricultural sector trends and policy context

Agriculture's contribution to the economy is small but its environmental impact significant. Between 1990 and 2004 farming's contribution to GDP and employment almost halved to 0.8% and 1.8% respectively by 2004 (Figure 3.29.1). Farming generates both environmental costs, calculated at approximately GBP 1 450 (EUR 2 100) million annually (2003 prices), and benefits, estimated at about GBP 1 230 (EUR 1 780) million annually, around 0.13% and 0.11% respectively of GDP in 2003 [1, 2, 3].

The agricultural sector has been contracting. The volume of farm production declined by over 8% during the period 1990-92 to 2002-04, together with a reduction in the volume of purchased farm input use, including –6% for pesticides, –13% for inorganic nitrogen fertilisers, –19% for inorganic phosphate fertilisers, and –24% for direct on-farm energy consumption (Figures 3.29.2 and 3.29.3). Grazing livestock is the dominant sub-sector, with livestock farming accounting for two-thirds of agricultural land use, with much of the rest under arable crops, largely concentrated in Central and Eastern England [4, 5].

Farming is mainly supported under the Common Agricultural Policy (CAP), supplemented with national expenditure within the CAP framework. Support to EU15 agriculture has declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate) compared to the OECD average of 30% [6]. Nearly 70% of EU15 farm support was output and input linked up to 2004, but this share was over 98% in the mid-1980s. Budgetary support to UK farmers in 2004 was GBP 2.8 (EUR 4.1) billion per annum, of which 80% is funded by the EU. Administration of agricultural policy is devolved to England, Wales, Scotland, and Northern Ireland.

Expenditure on agri-environmental programmes increased five-fold between 1993-2004, rising to GBP 245 (EUR 360) million [4]. Following the government's 2002 Strategy for Sustainable Farming and Food [1, 7], together with the Rural White Paper [8, 9] and CAP reforms, agri-environmental programmes are being further developed to encourage sustainable practices across all farms and to continue with conservation of high priority habitats and landscapes [10]. Support is also provided for conversion to organic farming, while voluntary Codes of Good Agricultural Practice (soil, water, air) encourage farmers to minimise water and air pollution and maintain soil quality [11].

Agriculture needs to respect national environmental and taxation policies and international environmental agreements. The *Bioenergy Infrastructure Scheme* provides grants to farmers to expand biomass and bioenergy production, linked to consumer tax reductions for biodiesel and bioethanol. Diesel fuel tax is reduced by nearly 90% for farmers, involving around GBP 220 (EUR 321) million annually (2005) of budget revenue forgone. National targets for farmland priority species and habitats are included under the *Biodiversity Action Plan*, as part of the broader commitment under the *Convention on Biological Diversity* (CBD). Farming is affected by commitments under international environmental agreements, which in addition to the CBD, include lowering: nutrient loadings into the North Sea (*OSPAR Convention*); ammonia emissions (*Gothenburg Protocol*); methyl bromide use (*Montreal Protocol*); and greenhouse gases (GHGs) emissions under the *Kyoto Protocol*. A climate change levy was introduced in 2001 to encourage businesses, including farming, to improve their energy efficiency and further reduce GHGs. Depending on the type of energy used (*e.g.* coal, gas) the levy in 2005 varied from GBP 0.07-0.43 pence/kilo Watt hour (kWh) (EUR 0.1-0.63 cents/kWh), although the horticultural sector was provided a 50% rebate on the levy until 2006 [12].

3.29.2. Environmental performance of agriculture

With a high population density, pressure on land resources in the UK is intense. Agriculture accounting for 67% (2002-04) of the land area, provides about two-thirds of UK food and areas for recreational activities [4, 13]. The area farmed has declined by 10% from 1990-92 to 2002-04 (Figure 3.29.2), with land mainly converted to forestry, urban use or fallow [14]. While the UK has a temperate maritime climate, the frequency and severity of flooding has increased, with about 12% of farmland in England (around the year 2000) located in areas prone to flooding [15]. Farmers face environmental challenges with respect to water pollution, biodiversity and landscape conservation, and air pollution from ammonia.

Soil losses from cultivated land are generally low, at less than 5 tonnes/hectare [16, 17], with farming contributing about 95% of erosion [5]. In some localities erosion can exceed 100 tonnes/hectare, with about 25% of England and Wales at moderate to very high risk, predominantly arable and rough grazing land [3]. Concern has shifted from on-farm to off-farm impacts of soil erosion [18]. The off-site costs of soil erosion from farmland, are estimated at GBP 9 (EUR 15) million annually, mainly the costs of dredging rivers of soil derived from farms [19], while soil compaction is also beginning to be recognised as increasing the risk of flooding [20]. The main causes of soil erosion are related to land left uncovered over winter, the use of heavy machinery and areas subject to high livestock densities [17]. While there has been a loss of soil organic matter (SOM) in arable and rotational grassland topsoils between 1980 and 1996 [4, 21], this is not considered to have damaged soil fertility [14], although impacts on soil biodiversity and soil health are

unclear [22]. Loss of soil organic carbon, a principal component of SOM, reduces soil carbon stocks which has implications for climate change [23, 24].

Agriculture is a major source of water pollution entailing high costs. As urban and industrial water pollution is largely controlled, diffuse pollution, is becoming comparatively more important especially farm run-off of nitrates, phosphorus, pesticides and pathogens, mainly of agricultural origin and concentrated in England. The overall cost of water pollution from agriculture was estimated in 2003/04 at around GBP 500 (EUR 725) million annually, contributing over 40% of total water pollution costs [25]. Nearly half of the prosecutions for pollution by the agricultural sector in 2002-03 were related to water pollution incidents [13], mainly from the dairy sector [3, 26]. Almost 5% of *Sites of Special Scientific Interest* (*e.g.* bogs, upland heath) in England in 2005 were in an unfavourable condition because of agricultural water pollution [4].

Nutrient surpluses from agriculture have declined, but are a major source of water pollution. While tonnes of nitrogen and phosphorus surpluses decreased over the period 1990-92 to 2002-04, mainly due to lower livestock numbers, and reduced fertiliser use, especially since 1996 (Figure 3.29.3). The intensity of nutrient surpluses (expressed as kg of nutrient per hectare of agricultural land) was higher than the EU15 and OECD averages for phosphorus, but around half these averages for nitrogen (Figure 3.29.2). About 60% of sewage sludge is recycled and applied to farmland, saving GBP 21 (EUR 31) million annually in fertiliser costs [15]. Following a ruling by the European Court of Justice that the UK had failed to comply with the EU *Nitrate Directive*, the area designated as *Nitrate Vulnerable Zones* was increased in 2004 to over 50% of the land area in England (2% in Wales and 14% in Scotland) compared to 8% in 1996 [5].

Agriculture accounts for 60% of nitrates and 29% of phosphates into surface water in England and Wales, and 50-70% of nitrates and almost 40% of phosphorus into coastal waters [5, 27, 28, 29]. Nutrients are in excess of drinking water standards in 30% of monitoring sites for nitrates in surface water (15% in groundwater) and over 50% for phosphorus. Almost 80% of water catchments are affected by eutrophication, with around half identified as a serious environmental issue [15]. Over 80% of fresh water aquatic ecosystems designated as *Sites of Special Scientific Interest* show symptoms of being eutrophic with a loss of aquatic species [27].

Pesticide use declined by 6% during the period 1990-92 to 2001-03 (sales volume in active ingredients), but the trend has been variable, linked to changes in cropping patterns and weather conditions (Figure 3.29.2) [30]. Farming uses almost 90% of pesticides [3], and accounts for most pesticide water pollution incidents [30]. Removing pesticides from drinking water supplies is estimated to cost around GBP 110 (EUR 160) million annually [27]. Over half of the farmed area in England and Wales on which pesticides were applied in 2002 qualified as "acceptable risk", based on EU criteria, with a further 30% of the area with buffer zones to reduce pesticide pollution, and the remaining 20% on which pesticides were applied was either unquantified or had an unacceptable risk [30]. Pesticide incidents involving terrestrial wildlife remain a concern, although the area of cereal field margins, which can help to reduce these incidents increased from under 5 000 to over 40 000 hectares from 1997 to 2004, while the area under crop protection management plans is also expanding [30].

Growth in water use by agriculture (+10%) was below that by other users (+16%) over the period 1990-92 to 2001-03, but the share of agriculture in total water use was only 10% (for England and Wales only) (Figure 3.29.2). Increasing water use is linked to the expansion in

irrigated area, about 2-3%/annum (although the share of total arable and permanent cropland irrigated is only 3%), and the shift to crops requiring higher quantities of water, such as maize. By 2020 climate change impacts may lead to a 20% increase in water for irrigation from current levels [31]. Farm storage of water has increased over recent years [19], but only 30% of the area irrigated is under efficient water supply systems, while water charges for agricultural use are lower than those for industry or households, although water charges paid by farmers are rising.

There has been a reduction in air polluting emissions from agriculture since 1990. Ammonia emissions declined, largely due to declining livestock numbers and fertiliser use (Figures 3.29.2 and 3.29.3) [4]. Agriculture accounted for nearly 90% of total ammonia emissions (2001-03), with livestock accounting for around 90% of agricultural ammonia emissions. Deposition of ammonia above critical loads occurred for a number of semi-natural habitats over large areas of the UK [4, 32]. To reach the total ammonia emission target under the *Gothenburg Protocol* a further reduction of total emissions by 5% from 2001-03 to 2010 will be required, which compares to a reduction of 16% achieved over the period 1990-92 to 2001-03. For ***methyl bromide*** (an ozone depleting substance), mainly used for soil fumigation in the horticultural sector (*e.g.* strawberry and lettuce growing), use was cut over the 1990s as agreed under the *Montreal Protocol*, which seeks to eliminate all use by 2005. But in 2005 a "*Critical Use Exemption*" (CUE) was agreed up to 81 tonnes (ozone depleting potential), or about 3% of the EU15's CUEs, which under the *Protocol* allows farmers more time to find substitutes.

Agricultural greenhouses gas (GHG) emissions declined by 13% from 1990-92 to 2002-04, and in 2002-04 accounted for 7% of total GHG emissions (Figures 3.29.2 and 3.29.4). This reduction was close to the 11% decrease for total national GHG emissions, and the 12.5% cut agreed as the commitment under the *Kyoto Protocol* by 2008-12 as part of the EU *Burden Sharing Agreement*. But farming is the major source of nitrous oxide (nearly 70%) and methane GHGs (nearly 50%) (Figure 3.29.4) [4, 33]. Projections suggest that the declining trend of agricultural GHGs will continue over the next 20 years [14], down to 32% below 1990 levels by 2010 (Figure 3.29.4) [12]. The loss of ***soil organic carbon*** in agricultural soils is a concern in terms of reducing agriculture's GHG soil sequestration capacity [34], however, changes in land use from farming to woodlands, and the expansion of agricultural biomass feedstocks for renewable energy is helping reduce GHG emissions [12].

Overall direct on-farm energy consumption by agriculture declined by 24% between 1990-92 and 2002-04 (Figure 3.29.2), compared to an 8% increase across the economy, and accounted for less than 1% of total energy consumption in 2002-04 [12]. There was a five-fold increase in electricity generated from farm wastes between 1995-2003 [4], although at present ***agricultural biomass feedstocks*** account for under 2% of electricity and heat generation and less than 0.1% of total transport fuel sales [35, 36].

Pressures from farming on biodiversity continue [15]. While agriculture, as the major land user remains a key threat to habitats and wild species, the growth in the area under agri-environmental schemes is beginning to ease the pressure [15, 37]. Over (and under) grazing practices, loss of mixed farming systems and semi-natural farmed habitats (*e.g.* grasslands), drainage, moor burning, and pollution are the main pressures from agriculture on biodiversity [4, 15, 37, 38]. The trends for ***agricultural genetic resources*** are unclear, although an inventory of *in situ* plant genetic resources is underway [39] and *ex situ* plant accessions are extensive, while for livestock all endangered breeds are under a conservation programme [40].

For agricultural habitats, there has been an overall net loss of farmland to forestry and urban use (6% over the 1990s), a reduction in semi-natural farmed habitats, a 3% increase in cultivated land to improved grassland, and expansion of woodlands on farms. Despite the slower rate of semi-natural habitat loss (*e.g.* grasslands) and the increase in farm woodland cover, the quality of remaining habitats may have deteriorated [13, 41]. But 60% of agricultural designated *Sites of Special Scientific Interest* (SSSI) were in a favourable or recovering condition in 2005 in England, although this compares to nearly 70% for all SSSI [4]. The main agricultural causes for unfavourable conditions on SSSI include a combination of overgrazing, moor burning, and drainage [4].

Wild species are under continued pressure from agriculture. For wild species on agricultural land a survey of ***wild flowering plants***, from 1987 to 1999, showed a decrease in the frequency of wild plants on arable and grassland (except on improved grassland) [see 42, supported by other research 43, 44]. The Government's indicator of ***wild bird populations*** shows that overall populations were 10% higher in 2004 compared to 1970, but for farmland birds they are under 60% of their 1970 level. The decline in farmland bird populations have been associated with changes in agricultural practices, including the loss of mixed farms, the switch to autumn sowing of cereals, and the loss of field margins and hedges. Since the late 1990s the farmland bird indicator, however, has remained fairly stable (Figure 3.29.3) [45], although there are regional differences, with northern parts of England showing a recovery in farmland birds since 1994 [46]. For other fauna (*e.g.* mammals, butterflies), incomplete evidence suggests that farming continues to pose a major threat to wild species diversity and abundance [15, 47].

Agriculture generally maintains cultural landscape features, but deterioration in quality is a concern [19]. Linear landscape features on agricultural land (*e.g.* hedges, stone walls) increased by about 3% between 1990 and 1998, while the number of ponds rose by 6% [5, 21]. However, the quality of some of these features is deteriorating, with over 50% of stone walls in poor or derelict condition and a decline in remnant (historic) hedges [41]. The reduction in mixed farming systems and semi-natural habitats is also adversely impacting on the quality of agricultural landscapes [13, 41]. About one-third of all archaeological sites are in ploughed sites, with 2% at high risk, while farming has contributed to 10% of the destruction and 30% of the damage to ancient monuments since 1945 [17, 48]. There are concerns for biodiversity and landscapes in some extensive upland farmed areas, which agri-environmental schemes are seeking to address. In Wales and Scotland, especially, afforestation on farms poses a threat to bird species of conservation value and has led to a loss of farmed landscapes [49, 50].

3.29.3. Overall agri-environmental performance

With the contraction of agriculture pressure on the environment has eased. This has been supplemented by less environmental pressure per unit of production, as the rate of reduction in some inputs (fertilisers and energy) has been greater than the decline in production, plus there has been a rapid growth in the area under agri-environmental schemes. But given the intensity of farming systems (notably in South, Central and Eastern parts of England) and the extent of diffuse agricultural pollution, the management and conservation of soils, water, biodiversity and landscapes, remain priority environmental issues [15]. It should be noted, however, that there are a range of potential external factors (*e.g.* CAP health check, commodity prices, demand for energy crops) that could see an increase in the intensity of agricultural production, and consequently lead to an associated rise in environmental pressures.

The UK has a good record in monitoring agri-environmental performance. About GBP 1.6 (EUR 2.4) million is available annually for monitoring the effectiveness of agri-environmental schemes in England. The *Sustainable Development Indicators* [21], the *Countryside Survey* [41], and various bird [45] and pesticide monitoring programmes [22], all track environmental performance [15, 51]. But monitoring trends in flora and fauna (except birds) and soil quality [18, 20, 52, 53] are weak, as is co-ordination of information across agencies and the devolved administrations [15]. The use of environmental impact assessment is limited, but being extended to cases involving the conversion of uncultivated and semi-natural land to intensive farming [15]. Moreover, the *Agriculture Change and Environment Observatory Programme* (2005) will monitor and assess the environmental impacts of farming [54].

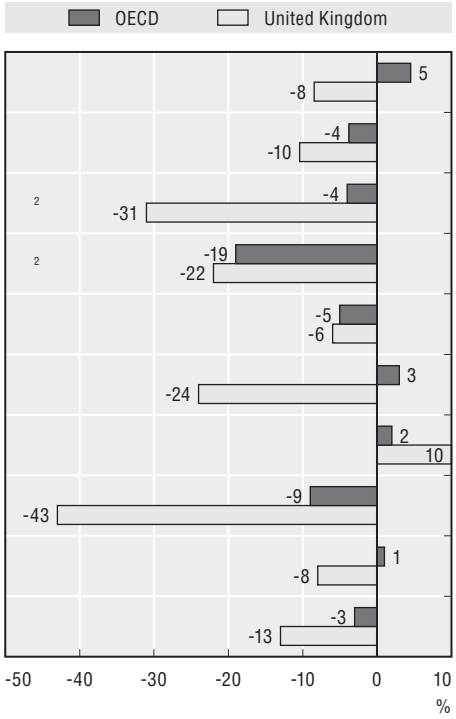
Wider coverage and changes to agri-environmental schemes could enhance their performance. Over 25% of the UK agricultural land area was under some form of environmental programme by 2006, compared to less than 1% in the early 1990s. In addition to the continuation of existing schemes, the government introduced from 2005 *Environmental Stewardship*, consisting of three elements: *Entry Level Stewardship* providing farmers up to GBP 30 (EUR 44) per hectare, such as for maintaining hedgerows, leaving conservation strips for biodiversity conservation and to cut diffuse pollution; the *Higher Level Stewardship*, targets high priority and endangered habitats and landscapes; and the *Organic Entry Level Stewardship*, is designed to encourage organic farming systems, with payments of GBP 60 (EUR 88) per hectare [55]. About 4% of UK farmland was under ***organic production*** in 2005, with around 2% of the livestock numbers under organic systems [4]. The three schemes together have funding of GBP 150 million (EUR 221 million), half of which comes from EU co-financing. Similar schemes are being introduced in Scotland, Wales and Northern Ireland. The UK has also launched an action plan toward sustainable soil management [56], and is planning to further increase energy crop production under the *Energy Crops* scheme [12].

Despite the growth in agri-environmental schemes a number of environmental problems persist. Diffuse water pollution from farming is a key concern with the share of farms under nutrient management plans less than 5%. The voluntary approach used to address agricultural water pollution is currently under review [15]. Under the EU *Nitrates Directive* a four-yearly review is required to assess the effectiveness of *Action Programme* measures, and according to the UK's Department for Environment, Food and Rural Affairs there is a strong likelihood that revised *Action Programme* measures could impose stricter measures on some farmers. Tax exemption on diesel fuel used by farmers provides a disincentive to improve ***energy efficiency*** and help further reduce GHGs, although both direct on-farm energy consumption and agricultural GHG emissions have been reduced (Figure 3.29.2).

Halting the long term decline in the quantity and quality of biodiversity and landscapes associated with farming is also a policy priority. Agri-environmental schemes are the main mechanism to help alter this trend, and success may depend on the balance of the uptake under the new *Environmental Stewardship* scheme between low cost options, applied widely across the country, and higher cost options targeting specific habitats and wild species [57]. The restoration of some semi-natural habitats (*e.g.* grassland) may take more than a decade [36, 58, 59]. Also the conservation of wild species by creating semi-natural habitats on farms (*e.g.* field margins), will depend on improvements in their management, habitat structure and the cultivars used in these areas [58, 59].

Figure 3.29.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

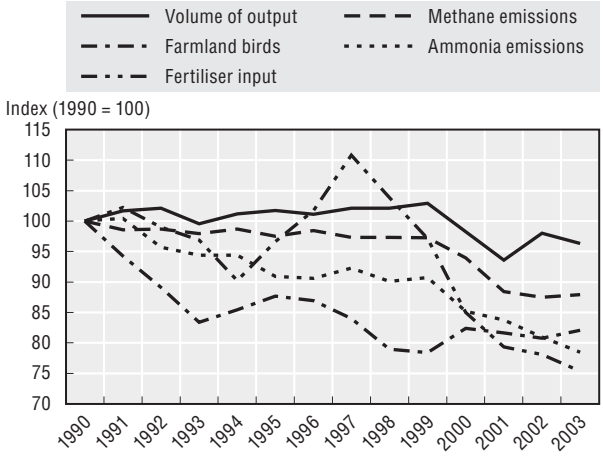
Variable	Unit		United Kingdom	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	92	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–1 883	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	43	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	13	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–1 996	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–309	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+129	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	0.6	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–25	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–6 912	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

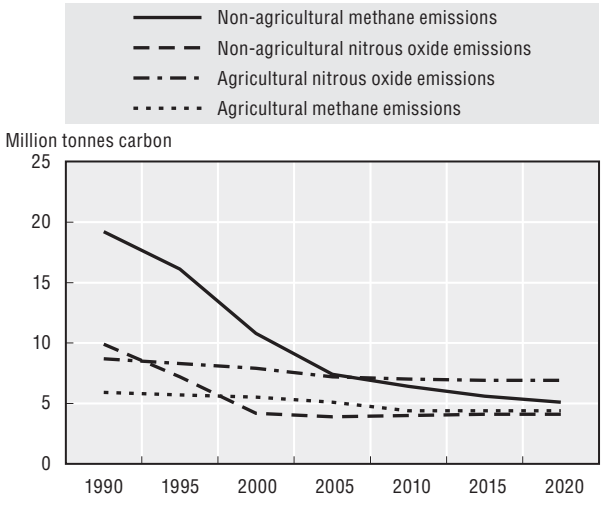
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.29.3. **Agri-environmental trends**



Source: Fertiliser Input (Defra-British Survey of Fertiliser Practice), *Farmland Bird Index* (Defra, Royal Society for the Protection of Birds and British Trust for Ornithology), *Volume of Output* (Defra-Agriculture in the UK), *Methane and Ammonia Emissions* (Defra-Digest of environmental Statistics and Netcen). Netcen is now part of AEA Energy and Environment.

Figure 3.29.4. **Greenhouse gas emission trends and projections**



Source: UK, Department of Environment, Food and Rural Affairs.

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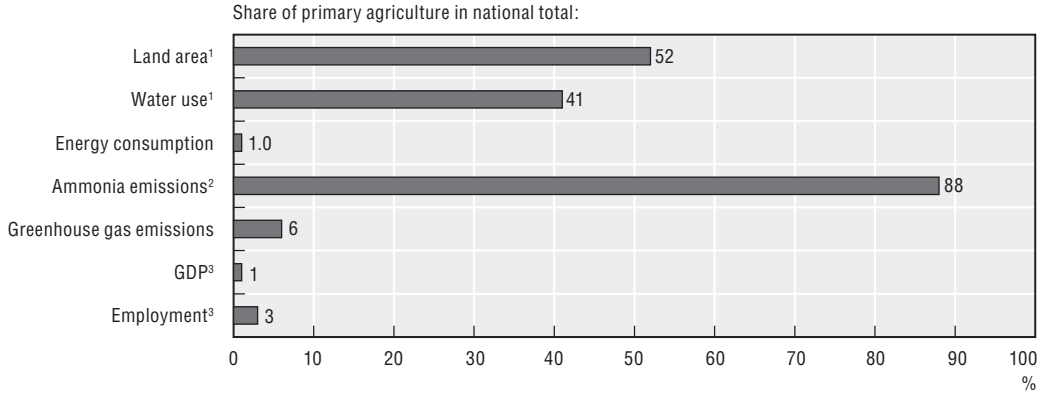
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3.30. UNITED STATES

Figure 3.30.1. **National agri-environmental and economic profile, 2002-04: United States**



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1. Data refer to the period 2005.
2. Data refer to the period 2000.
3. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.30.1. Agricultural sector trends and policy context

Agricultural growth has been amongst the most rapid across OECD countries since 1990 (Figure 3.30.2). Nevertheless, agriculture's contribution to the economy has been declining and currently accounts for less than 1% of GDP and under 3% of employment (Figure 3.30.1). Steady global economic growth and gains in population, particularly in developing countries, have strengthened demand for food and agricultural products, and provided a foundation for gains in world agricultural trade, including US agricultural exports. In addition, large growth of US bioenergy industries is increasing demand in the agricultural sector [1].

About 8% of the 2 million US farms account for 70% of the value of farm production on 30% of agricultural land [2, 3]. However, smaller farms (*e.g.* retirement, residential and farms where sales are a small share of household income) are important in terms of agri-environmental performance as they operate on 60% of farmland and account for around 60% of agri-environmental payments [4].

Agricultural support is currently below the OECD average but above the levels of the mid-1990s. Producer support declined from 22% of farm receipts in the mid-1980s to 13% in 1995-97 but rose to 17% by 2002-04 (as measured by the OECD's Producer Support Estimate) compared to the OECD average of 30% [5]. The share of support that is most production and trade distorting has declined from 69% of support in the mid-1980s to 66% in 2002-04. The basic legislation governing farm policy for 2002-07 is the *Farm Security and Rural Investment Act of 2002* (the *2002 Farm Act*). Support is provided through budgetary

payments, loans and interest concessions, minimum prices with government purchases, as well as some import restrictions and export subsidies. Border protection with Canada and Mexico is being reduced under the *North American Free Trade Agreement* (NAFTA).

Agri-environmental programmes form a growing dimension of agricultural policy. The Conservation Reserve Program (CRP) aims to remove from production highly erodible (HEL) and other environmentally sensitive cropland, while the Wetlands Reserve Program (WRP) seeks to re-convert farmland to wetlands. In exchange for annual payments, land is generally enrolled in the CRP for a period of 10-15 years, but contracts can be renewed. Wetlands restored through WRP may be subject to 30 year or permanent easements. Under the Environmental Quality Incentives Program (EQIP) and the Wildlife Habitat Incentives Program (WHIP) payments defray costs for respectively adopting sustainable farming practices, such as for soil and water quality conservation, and providing wildlife habitat. The Farm and Ranch Lands Protection Program (FRPP) aims to avoid productive farm and ranch land being converted into urban use by purchasing the development rights of farm properties. Cross-compliance provisions also require that to receive payments under commodity programmes farmers must not cultivate HEL (sodbuster) without using a suitable soil conservation system or drain wetlands (swampbuster).

The 2002 Farm Act substantially increased funding for agri-environmental policies. For the period 2002-07 funding was USD 3.5 billion annually, a 75% increase over the annual spending for 2000-02 of USD 2 billion annually which was 8% of budgetary payments. The *Farm Act* expanded the CRP and WRP but its emphasis shifted to supporting conservation practices on working farmland, especially under EQIP [6]. In addition, two measures, the *Conservation Security Program (CSP)* and the *Grassland Reserve Program* (GRP), implemented in 2002 and 2003 respectively, further strengthened these efforts. The CSP pays farmers who have met a high standard for environmental performance to adopt or maintain practices to further enhance environmental performance, such as improving soil and water quality or wildlife habitat; while the GRP aims to preserve and improve native grass species. The *Farm Act* also supports technical advice and research to promote sustainable farming.

Economy-wide environmental and taxation policies also impact on agriculture. Between 1994 and 1998, seven agencies provided USD 3 billion annually to address nonpoint source pollution [7, 8]. The *Clean Water Act* (CWA) has responsibility for reducing water pollution, but nonpoint sources of pollution such as agriculture are not directly covered by the CWA [7, 9], although large confined animal feeding operations require pollution permits and implementation of comprehensive nutrient management plans [10]. Policies affecting agricultural water pollution are mainly implemented at the State level, using a mix of measures that vary across States, such as restrictions and taxes on fertiliser and pesticide use, and payments for the adoption of best management practices [4, 11]. However, financial assistance in the form of agri-environmental payments comes primarily from the Federal government, affecting water quality both directly (*e.g.* EQIP) and indirectly (*e.g.* CRP, WRP), as adoption of soil and water conservation practices can help to reduce off-farm flows of soils, nutrients and pesticides into water bodies [4, 10, 12, 13]. Also the *Great Lakes Water Quality Agreement*, between the US and Canada [14] addresses concerns related to agricultural water pollution.

The Federal Energy Policy Act of 2005 mandates that by 2012 a minimum of 7.5 billion US gallons (28 billion litres) of ethanol be blended into gasoline. Ethanol is a substitute for MTBE (a water contaminant) as a fuel oxygenate, and has the potential to reduce

greenhouse gas emissions [15]. A tax exemption is provided for the use of ethanol and assistance granted to develop ethanol production facilities. There are exemptions on Federal fuel taxes for on-farm machines and vehicles, equivalent to USD 2 385 million of annual budget revenue forgone over the period 2004-06 [5]. Government expenditure on agriculture's share of the interest subsidy on long-term loans for initial capital investment in public irrigation projects amounted to USD 269 million annually over the average period 2004-06 [5]. In terms of international environmental agreements with implications for agriculture, the US is a signatory to the *Montreal Protocol*, which provides a phase out period for the ozone depleting methyl bromide pesticide, and the *Gothenburg Protocol* on long-range transboundary air pollution, which includes ammonia.

3.30.2. Environmental performance of agriculture

Soil, water and biodiversity issues dominate agriculture's impact on the environment. Specifically, farming's main environmental impacts are on soil erosion, water pollution, competition for water resources between irrigators and other users, and on wildlife habitats and species. Other agri-environmental issues, but of lesser importance, relate to air emissions.

Agriculture is the major user of land and water resources. The sector accounted for about 52% of land use and 41% of freshwater withdrawals in 2005 [4]. About 30% of grassland pasture and range and forest land is owned by the Federal government, although most land under arable and permanent crops is privately owned [16]. There exists a vast range of agro-ecological regions and climatic zones affecting agriculture. While population density is low by OECD standards [17], there is growing competition between agriculture and other users for land (especially in Southern and Eastern States) and water resources (especially in Western and Central States), including demand on these resources for recreational and environmental uses [7].

Soil erosion is a significant problem but its damage to farmland productivity and the environment has been reduced. About 60% of total soil erosion originates from agriculture, with the remainder resulting from other economic activities (*e.g.* forestry) and natural events (*e.g.* floods and droughts) [18]. Erosion types vary between regions, for example, Western States suffer more from wind erosion while the East is prone to water erosion (Figure 3.30.3). Between 1982-2003 the cropland area eroding at excessive rates decreased by over 40%, and by 2003 approximately 72% of total cropland area was within tolerable erosion levels (Figure 3.30.3) [18]. Farms under agri-environmental programmes that target HEL, experienced a significant reduction in erosion rates [19, 20]. However, 50% of erosion reduction on HEL since the 1980s has been due to land conversion to other uses (*e.g.* to forestry), while erosion rates also declined on land not under Federal programmes [19]. The off-farm damage from soil erosion (*e.g.* costs of dredging rivers, losses to recreational values) are estimated at over USD 2 billion annually [7, 21].

Farm soil quality is also impaired by other less widespread and costly degradation processes. About 5% of farmland is affected by soil salinity, largely associated with poor irrigation practices, although in some States (*e.g.* Montana) salinity is impacting on an increasing area [22]. Soil compaction is a problem mainly in the Corn Belt, resulting in yield losses estimated at USD 100 million annually [22]. However, there is no national database to monitor trends in these physical and chemical soil processes, nor for the biological conditions of the soil [23, 24].

Agriculture is a major and widespread source of water pollution. Overall the quality of water bodies is improving and drinking water standards are high, but in 2000 about 40% of rivers, 45% of lakes and 50% of estuaries were below the Federal guidelines set for recreational and environmental uses [25]. Agriculture is responsible for 60% of river pollution, 30% of lake pollution, 15% of the pollution in estuarine and coastal areas, and is the major source of groundwater pollution [8, 25].

Rising levels of agricultural nitrogen and phosphate surpluses over the period 1990 to 2004 risk increasing water pollution (Figure 3.30.2). Nutrient sources and types in watersheds vary greatly across regions. Fertiliser run-off is important in Midwestern States and run-off from livestock manure in the Mississippi Basin and some Eastern States [26], while phosphorus loadings are high in the Southeast and nitrogen in the Mississippi basin [4, 27]. Part of the problem of nutrient surplus disposal is linked to a greater number of confined animal feeding operations, with over 60% of manure produced on farms that cannot fully absorb the waste [28, 29]. But use of inorganic fertilisers rose by 6% for nitrogen and 4% for phosphate fertilisers, between 1990-92 and 2002-04, compared to a 15% increase in crop production volume over this period, resulting in a lowering of cropland fertiliser use intensity.

In agricultural areas nutrients levels in rivers and wells have exceeded Federal drinking water standards. Between 1995 and 2005 about 10% of rivers and 20% of wells exceeded Federal drinking water standards for nitrates in agricultural areas, and 75% of rivers had phosphorus levels above Federal guidelines to prevent excess algal growth [23]. Agricultural nutrient pollution of the Gulf of Mexico accounts for 75% of nitrogen discharges and nearly 50% of phosphorus, derived mainly from the Mississippi basin [30], leading to oxygen deficient water causing algal blooms that damage marine life and commercial fisheries [23, 30, 31, 32]. Water quality in the Great Lakes is also being impaired by agricultural nutrient run-off [14, 26], including pathogens from livestock production [14]. Water pollution from livestock pathogens and other related wastes is a growing problem, but at present there is no national monitoring of these pollutants [4, 33].

Pesticide use (quantity of active ingredients) decreased since 1990, with pesticides frequently detected in water but usually at low levels [8]. Agriculture currently accounts for about 75% of total pesticide use [34], and a 4% decrease in pesticide use (1990-92 to 2001-03, Figure 3.30.2) compared to a 15% growth in crop output over the period 1990-92 to 2002-04, indicates the reduction in the intensity of pesticide use. Over the period 1992-98 at least one pesticide was detectable throughout the year in all rivers and 60% of wells, although only 4% of rivers and less than 1% of wells had pesticides that exceeded Federal drinking water standards. But over 80% of rivers had pesticide concentrations exceeding aquatic life guidelines [23], and pesticides in reservoirs have higher concentrations than for rivers [7]. Some highly persistent pesticides, such as DDT, were detected in fish in about 30% of rivers in agricultural areas in the early 2000s, despite being prohibited for more than 30 years [8, 35]. Vulnerability to pesticide leaching varies considerably (related to a variety of factors soils, crop types, climate, etc.), but the greatest vulnerability is in the crop and horticultural growing areas of the Corn Belt, Southeastern States, the Southern Plains, the Lake States and California [7].

Higher national demand for water is putting pressure on water supplies, although overall agricultural water use declined by 2% from 1990 to 2000 (Figure 3.30.2). Irrigators are the major users of agricultural water use, with much of the remainder used by livestock producers. The availability of water for agricultural purposes is uneven, and shortages occur in some areas and in some years. In the arid West, drought conditions place

increased demands on non-renewable supplies [4]. The area under irrigation rose by 12% from 1992 to 2002, accounting for approximately 5% of the total agricultural area but providing nearly 50% of the total value of crop sales [4, 36]. Total irrigation withdrawals declined by 12% between 1995-2000 with groundwater withdrawals increasing slightly (3%) and a 16% reduction in surface water withdrawals. Despite the recent decline, surface water provides nearly 60% of irrigators' water needs [4, 37]. Hence, irrigation accounted for about 75% of total groundwater withdrawals in 2000, and an even higher share in many Western and Southern States [37]. Despite the reduction in surface water use by irrigators the overexploitation of some rivers, especially in times of drought, has threatened aquatic ecosystems, such as in the Klamath Basin which has led to Federal restrictions on water supplies to agriculture in this Basin [38]. Of the nearly USD 17 billion irrigation construction expenditure for projects constructed over the last 100 years, and considered reimbursable by the Federal government, irrigators have been allocated USD 3.4 billion to be repaid at zero interest [7]. Water charges are considerably lower than retail prices paid by industrial and urban users [7, 9, 39].

Irrigated agriculture is depleting groundwater resources beyond natural recharge rates in some regions. In the High Plains (Ogallala) aquifer, for example, which irrigates more than 20% of US cropland, the water level has fallen and is close to depletion in parts of Kansas and Texas [9]. In the Texas Panhandle groundwater depletion poses a serious threat to the sustainability of the current irrigated agricultural system and associated rural economy [40, 41]. Groundwater depletion is also the main cause of land subsidence in some areas, estimated to cost USD 100 million annually [42]. But there have been improvements in irrigation water use efficiency, including a decline in per hectare water application rates (Figure 3.30.2), and adoption of water conservation practices and technologies, although low-flow systems are used on only 5% of the total irrigated area [4].

Competition for water resources is also acute on the US-Mexico border, mainly because of population growth and demands from agriculture as a major user, leading to over exploitation of water from the Rio Grande on both sides of the border [43]. The *International Boundary and Water Commission* resolves water resource allocation issues, including irrigation, at the US-Mexico border.

Ammonia emissions from agriculture have increased significantly above the OECD average, but emissions from methyl bromide use have declined. Agricultural ***ammonia emissions,*** which represent nearly 90% of total ammonia emissions, rose by 15% over the period 1990-92 to 2000, compared to the OECD average increase of 1% (Figure 3.30.2). The *Gothenburg Protocol* seeks to cut ammonia emissions by 17% from their 1990 levels by 2010, although the US (a signatory to the *Protocol*) has not yet agreed on its emission ceiling targets. Acidification of soils and water from acidifying emissions, originating mainly in Mid-Western States, pose a problem for Eastern States, but the contribution of agricultural ammonia acidifying emissions is unclear [44, 45]. Reporting of ammonia emissions from intensive livestock operations has been required since 2004 [46]. The phase-out targets of emissions resulting from the use of ***methyl bromide*** (a widely used fumigant in agriculture which is an ozone depleting substance) under the *Montreal Protocol* have been met up to 2003. But the US has been granted an increase in "Critical Use Exemptions" (CUEs), which effectively gives more time for users to develop alternatives equal to about 60% of the total OECD CUEs in 2005 [47].

The rise in agricultural greenhouse gas emissions is above the OECD average, but soil carbon sequestration and bioenergy production is increasing. Agricultural greenhouse gases (GHGs) grew by 1% over the period 1990-92 to 2002-04, compared to a 3% decrease for the OECD, especially due to an expansion in crop production (Figure 3.30.2). Agriculture contributed 6% to total national GHG emissions in 2002-04 [48]. US cropland soils sequester about 32.2 million tonnes of carbon dioxide equivalent annually (or 8.8 million tonnes of carbon). ***This sequestration amounted to about 4% of total US terrestrial carbon sequestration in 2004.*** Annual soil sequestration rates in cropland have increased by 40% since the early 1990s [48]. The use of ***agricultural biomass for energy production*** grew by 25% over the 1990s, but still provides only about 3% of total energy consumption, less than 1% of transportation fuel mainly from maize based ethanol, and 5% of chemical product output [49]. Federal targets aim to increase these shares to 4% for energy and fuel, and to 12% for chemicals by 2010 [49], which could have significant impacts on crop production patterns, prices and international commodity markets [50, 51].

As the major land user agriculture has significant impacts on wildlife habitats and species. A US study of the CRP estimates that agriculture, as a provider of wildlife recreational activity, has led to an increase in recreational spending of USD 300 million annually under the programme [52]. Changes in farmland use that were potentially beneficial to wildlife included an increase in the share of cropland not cultivated from 11% in 1987 to 15% by 2001, and a net conversion of cropland to pasture [53]. A US study found that lands shifting in and out of crop cultivation are generally located in areas with more imperilled plant and vertebrate species than other croplands, but data were insufficient to determine whether these land-use changes had a positive or negative impact on imperilled species [54]. The spatial changes in farmland habitat are highly varied but not regularly monitored [55].

Wetlands, a key wildlife habitat, account for more than 7% of the non-federal area in the 48 contiguous United States [4]. Between 1992-97 to 2001-03 average annual losses of wetlands to agriculture were greatly reduced compared to the 1980s and offset by wetland restoration at an average net annual gain of nearly 30 000 hectares during 2001-03 (Figure 3.30.4) [56]. Research suggests that restored wetlands are quickly vegetated and colonised by a variety of wildlife species [57], but may take much longer to return to a "natural" state. The net effect on wildlife of land use changes, within and between agriculture and other uses, are more difficult to measure. Between 1992 and 1997, there was a net conversion of agricultural land to forestry and urban development, although this involved only about 1% of the total agricultural land area [58].

Increased use of chemicals, water and changes in farmland use has led to pressure on wildlife habitat and species. Agriculture was estimated in 1995 to negatively affect 380 of over 660 wild species listed as threatened or endangered [22]. Conversion of land for agricultural production and diversion of water for irrigation have had a particularly damaging impact on biodiversity since 1990 [59, 60]. Also pesticide and nutrient run-off are recognised as a widespread threat to terrestrial and aquatic ecosystems [23, 61, 62], with pesticides linked to the decline in pollinators which has reduced yields for certain crops [23, 63]. US research suggests, however, that taking cropland out of production under the CRP and WRP programmes may have had some beneficial wildlife impacts, such as the 30% increase in duck numbers attributed to the CRP [64]. In addition, a number of species have adapted well to specific agricultural systems, such as some mammals in the West [65]. In other cases the uptake of certain farming practices has been beneficial to wildlife, for example, the

avoidance of livestock polluting farm ponds and rivers in Minnesota [61], and in the Northeast the adoption of conservation tillage practices has increased the availability of crop residues in autumn and winter as a food source for bird and mammal populations [66].

About 55% of the global area under transgenic crops is in the US, with uncertainty in some of the environmental impacts. In 2006, transgenic crops accounted for 89% of the US planted area under soybeans, 83% for cotton, and 61% for maize. US farmers adopted herbicide tolerant (HT) varieties, which help control weeds, at a faster rate than insect resistant (Bt) varieties [67]. However, a noticeable trend in recent years is the rapid growth of cotton and maize varieties with both HT and Bt (stacked) traits. US studies indicate that the use of transgenic crops is associated with a lower overall volume of pesticide use, although pesticide use varies with the crop and the technology. There is a lack of consensus on the possible long-term impacts on biodiversity of using transgenic crops [13, 68]. Moreover, the degree of genetic erosion in crops remains the subject of debate [69]. However, yields for many major crops have been relatively stable as temporal diversity has replaced spatial diversity. Although there may be greater spatial uniformity of crops planted at any given time today, the release of new varieties with new resistance traits has been steady over time [69]. All major animal breeds in the US confront issues that include small effective population size, limited genetic diversity, and genetic erosion resulting from intense selection for some production traits [70].

3.30.3. Overall agri-environmental performance

Pressure on the environment is likely to continue with the projected expansion of the farm sector. The expansion of agricultural production, at a rate well above the OECD average, is exerting growing pressure on land, water, and biodiversity, especially in those areas where population densities are highest (*e.g.* the East Coast) or the growth rate is rapid (*e.g.* Southern States). With an expansion of the farm sector projected over the next decade the pressure on the environment and competition for natural resources from agriculture might intensify in these regions.

Monitoring and evaluation of agri-environmental performance is highly developed by OECD standards. Extensive and regularly updated databases at Federal, State and County levels exist for many agri-environmental issues. Drawing on these databases agri-environmental indicators and spatially referenced agri-environmental models to assist policy evaluation have been developed [71]. However, gaps exist, especially in tracking agriculture's impact on water pollution from livestock pathogens, on soils from damaging processes such as salinisation, and on biodiversity [23]. But efforts are being made to fill these data gaps, including developing a better understanding of agriculture's role in ecosystem service provision, such as soil carbon sequestration and biomass production [49, 72, 73].

Agricultural pressure on the environment since 1990 has been lowered in some cases, notably reduced rates of soil erosion, but is increasing for other indicators, especially groundwater depletion but also air pollution. The area of cropland suffering high rates of ***soil erosion*** has been significantly reduced, but about a quarter of cropland is still subject to high rates of erosion. Farming, the major contributor to ***water pollution***, is lightly regulated compared to other polluters [74]. Agricultural water pollution is widespread and increasing loadings of nutrients and livestock pathogens suggest the risks of water pollution from agriculture might be rising in areas where crop or livestock agriculture is intensifying, although pesticide use

declined over the period 1996 to 2003. Most rivers and wells meet Federal drinking water standards in farming areas, but many rivers, lakes, estuaries and coastal waters do not meet Federal guidelines to support recreational and environmental uses.

Competition for surface and groundwater resources between farmers and other users is becoming acute in drier areas. In some regions the use of groundwater by irrigators is substantially above recharge rates. Moreover, subsidising irrigation infrastructure and water charges as well as the energy costs to power irrigation facilitates, can be a disincentive to reduce water use or use it more efficiently. Overexploitation of groundwater is becoming more widespread and could undermine the viability of agricultural and rural economies in some regions [9]. Also subsidising on-farm fuel energy costs is a disincentive to improving energy use efficiency and reducing greenhouse gas emissions.

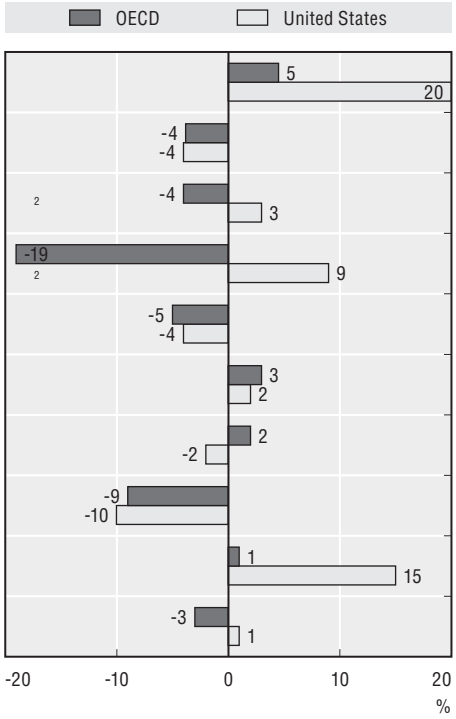
Air pollution from ammonia and greenhouse gases has increased above average OECD rates. Carbon stocks in agricultural soils, however, have risen and carbon emissions reduced as a result of bioenergy production from agricultural biomass.

Conversion of wildlife habitats to agricultural use, increasing water use and pollution, has been harmful to wildlife. But the overall pressure by agriculture on biodiversity appears to have eased, especially where cropland has been retired from production, including restoration of wetlands, and where changes in farming practices, such as conservation tillage, have enhanced habitat conditions on cropland leading to larger wildlife populations.

Policies are addressing many of the remaining agri-environmental challenges. The 2002 *Farm Act* has increased funding for agri-environmental measures up to 2007, including strengthening the CRP and WRP, and shifting emphasis towards programmes that support conservation practices on working farmland, especially the EQIP. According to US research these programmes have led to improved agri-environmental performance on many fronts. There are signs that farmers have increased fertiliser, pesticide, energy and water use at a much slower rate than the growth in the volume of agricultural production. These developments are in part due to the adoption of soil and water conservation practices by producers [19]. However, these impacts have been offset to some extent by output and input linked support to agriculture which raises production and increases pressure on the environment and thus the cost of achieving specific environmental goals [75].

Figure 3.30.2. **National agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

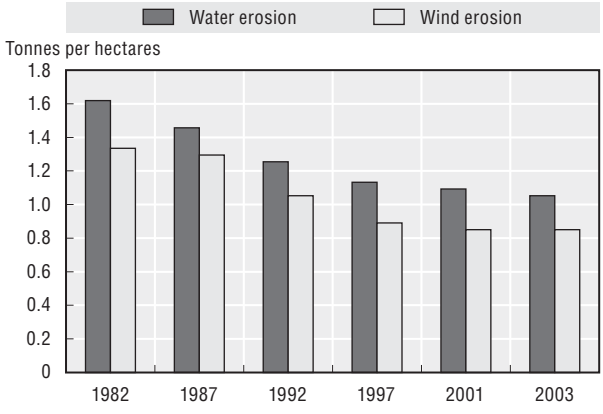
Variable	Unit		United States	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	120	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–17 074	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	37	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	3	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–11 944	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	+370	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	–3 645	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	8.4	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	+524	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	+4 806	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

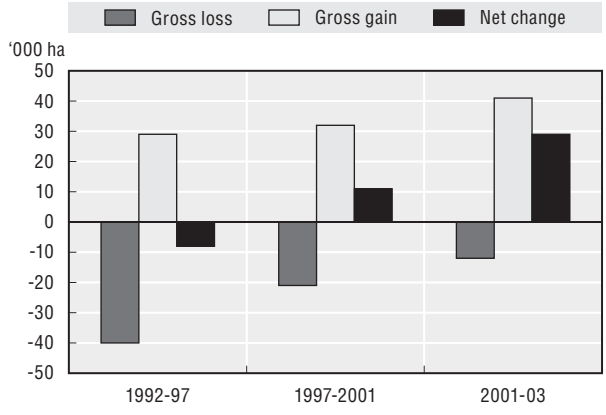
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

Figure 3.30.3. **Soil erosion on cropland**



Source: Natural Resources Conservation Service, United States Department of Agriculture.

Figure 3.30.4. **Change in palustrine and estuarine wetlands on non-federal land and water area**



Source: Natural Resources Conservation Service (2003), Annual National Resources Inventory.

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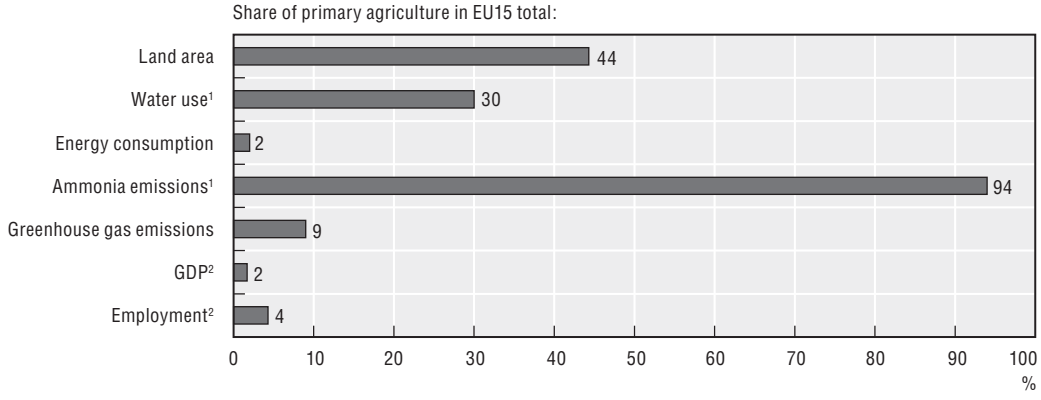
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3.31. EUROPEAN UNION

Figure 3.31.1. **National agri-environmental and economic profile, 2002-04: European Union (15)**



StatLink http://dx.doi.org/10.1787/301357140147

1. Data refer to the period 2001-03.
2. Data refer to the year 2004.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

3.31.1. Agricultural sector trends and policy context

Overall agricultural production in the EU15 has changed little over the past decade. Over the period 1990-92 to 2002-04 the volume of production rose by 2%, although the value of production increased by almost 30%, despite a nearly 5% reduction in the area farmed (Figures 3.31.2, 3.31.3 and 3.31.4). Agriculture accounted for around 2% of GDP and over 4% of total employment in the EU15 in 2003, but these averages mask great variation across EU member countries (Figure 3.31.1). There is also great diversity of production and farm structures in the EU agricultural sector, and that diversity has increased with the addition of 10 new member states in 2004 [1].

European agri-environmental trends highlight continuing challenges. The main source of agricultural production growth over the next 20 years is expected to arise from crop yield increases and improvements in livestock productivity, rather than any expansion in the area under cultivation or livestock numbers. Projections of EU15 wheat and coarse grains from 2007 to 2016, for example, suggest yields rising at around 1% per annum while the area cultivated is likely to be stable or slightly reduced [2]. Similarly for milk production, while cow numbers are projected to fall by nearly 1% per annum up to 2016, milk yields are expected to rise by over 0.5% annually [2].

The purchase of agricultural inputs, such as mineral fertilisers, pesticides, energy and water, are expected to increase considerably in certain new member states. This could lead to increased risks for water pollution and biodiversity, although the intensity of input use in the new member states is likely to remain lower than in most EU15 countries. Environmental

pressure is also likely to increase on water resources, especially as there has been a 7% increase in the EU15 area irrigated over the period from 1990-92 to 2001-03, compared to the OECD average of 8% over this period. Also demand for water is rising from other users in some EU regions, including the need to maintain water flows for the conservation of aquatic ecosystems (*e.g.* rivers, lakes and wetlands) [3]. Overall total water use across the EU15, however, decreased by 9% between 1990-92 to 2001-03.

Farming is mainly supported under the Common Agricultural Policy (CAP), together with additional national expenditure within the CAP framework. Support to EU15 agriculture has declined from 39% of farm receipts in the mid-1980s to 34% in 2002-04 (as measured by the OECD Producer Support Estimate) compared to the OECD average of 30%. Nearly 70% of EU15 farm support was output and input linked up to 2004, falling from over 98% in the mid-1980s [1]. Support to farmers includes agri-environmental measures (AEMs), for undertaking activities deemed as environmentally beneficial, with EUR 13.5 billion of EU15 co-financed payments for the period 2000-06 allocated for AEMs [4]

Agricultural support payments are increasingly subject to environmental cross-compliance requirements. Voluntary (for EU member states) cross compliance was introduced under the *Agenda 2000 CAP Reform* and became mandatory with the 2003 CAP Reform. As of January 2005, for farmers to receive the *Single Farm Payment*, they must comply with 19 *Statutory Management Requirements* (SMRs) – five of which are environmental – and with a number of standards to ensure the "good agricultural and environmental condition" (GAEC) of agricultural land (as set out in EC Regulation 1782/2003) [5, 6]. The SMRs are based on pre-existing EU directives and regulations, while GAEC is a new requirement and consists of eleven standards relating to soil erosion, soil organic matter, soil structure and a minimum level of maintenance of the land.

Agri-environmental payments largely focus on farm management practices to enhance environmental benefits. Support for agricultural management practices compatible with protection of environment was established under EU Council Regulation (EEC) No. 2078/92, which covered the period 1993-99, and was extended over the period 2000-06 under Regulation 1257/1999. Under these measures farmers are required to meet certain agri-environmental commitments for at least five years. These commitments go beyond the application of usual "good farming practice" (defined as the standard of farming which a "reasonable" farmer would follow in the region concerned), and must at least entail compliance with general environmental objectives (Regulation 445/2002). Support is granted annually and is calculated on the basis of: income forgone; additional costs resulting from the commitments; and the need to provide an incentive to alter practices. The maximum annual payments per hectare are: EUR 600 for crops; EUR 900 for specialised perennial crops; and EUR 450 for all other land uses. Payment rates vary between different measures and member states, but the average agri-environmental payment in 2001 was EUR 89 per hectare. Between 1993 and 2001 the total EU15 spending under these two agri-environmental regulations amounted to EUR 2.3 billion [4, 5].

Some agri-environmental payments are specific to organic farming. In 2001, a total of EUR 275 million was spent on organic farming, within the framework of agri-environmental measures, covering more than 18 000 holdings farming nearly 3 million hectares or about 4% of total EU15 agricultural land area (2002-04), compared to the OECD average of under 2%. The average annual payment rate for organic farming conversion is EUR 183 per hectare, which is higher than for the average of other agri-environmental

measures in all countries, except Portugal and the United Kingdom. Council Regulation (EEC) N° 2092/91 defines a conversion period of a minimum of two years before sowing annual crops and three years in the case of perennials. It also defines a method for organic production for crops and livestock, regulates the labeling, processing, inspection and marketing of organic products within the EU, and the import of organic products from non-EU countries [5, 7].

Agriculture is also affected by EU-wide environmental policies. In many cases these environmental policies are implemented in conjunction with the cross-compliance requirements mentioned above. The ***Nitrates Directive*** requires member states to designate as *Nitrate Vulnerable Zones* all areas of land where the corresponding surface water or groundwater contain more than 50mg nitrates per litre or where the corresponding freshwater bodies, estuaries, coastal and marine waters are found to be or risk being eutrophic. Member states must establish and implement mandatory measures for farmers located in these zones. The ***Directive on Integrated Pollution Prevention and Control*** requires member states to impose their own emission limits and other appropriate conditions in environmental permits, which are mandatory for potentially polluting plants of a given scale, including large-scale intensive poultry and pig operations.

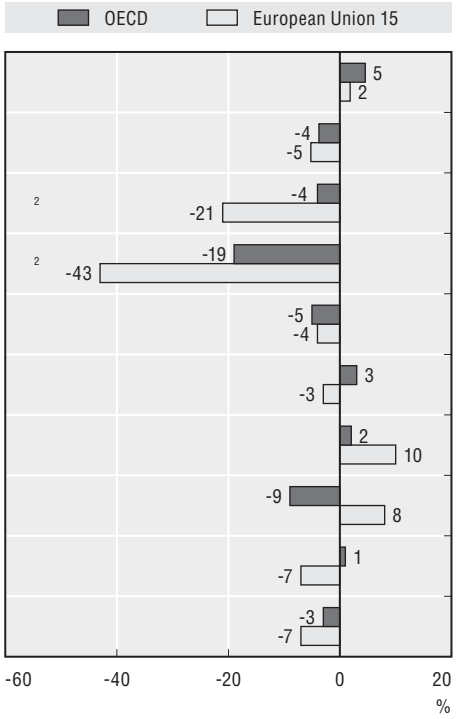
With regard to water quality, the Drinking Water Directive specifies limits for levels of nitrates, active ingredients of pesticides and residues from plant protection products, which member states are required to meet. The ***Groundwater Directive*** requires member states to take steps to prevent (limit) the introduction into groundwater of substances presenting a high risk of toxicity (low risk of toxicity, but potential harmful effect). The *Nitrates, Groundwater and Drinking Water Directives* are now part of the broader ***Water Framework Directive*** which requires member states to: develop by 2009 a Management Plan and a Programme of Measures for each river basin to protect, enhance and restore bodies of surface and groundwater; and ensure by 2010 that water pricing policies provide adequate incentives for users to use water resources efficiently [5].

Concerning biodiversity and soils, the ***Birds and Habitat Directives*** requires member states to take steps to protect all rare, threatened or vulnerable plant and animal species of community interest, and all wild bird species. In the case of soil as part of the EU's 6th *Environment Action Programme* [8], the EU has decided to adopt a ***Thematic Strategy on Soil Protection*** as part of its aim of protection and preservation of soils, including agricultural soils, which was adopted in 2006.

EU agriculture is also affected by a number of international environmental agreements. In most cases member countries sign and ratify these agreements and implement the necessary actions to comply with the agreements, unlike trade agreements, such as under the *World Trade Organisation*, where the EU signs and ratifies these agreements as a group and not through individual member states. Some international environmental agreements that affect agriculture are regional, such as the: North-east Atlantic (*OSPAR Convention*) and the Baltic Sea (*HELCOM Convention*) in relation to marine pollution from agricultural nutrients and pesticides; the Convention on the Conservation of European Wildlife and Natural Habitats (*Bern Convention*); and the European Landscape Convention. In other cases agreements are global, for example, the Convention on Long-Range Transboundary Air Pollution (*Gothenburg Protocol*); the *Montreal Protocol* on Substances that Deplete the Ozone Layers; the *Convention on Biological Biodiversity*; the *United Nations Convention to Combat Desertification*; and the *Kyoto Protocol* to the United Nations Framework Convention on Climate Change [9].

Figure 3.31.2. **EU15 agri-environmental performance compared to the OECD average**

Percentage change 1990-92 to 2002-04[1]



Absolute and economy-wide change/level

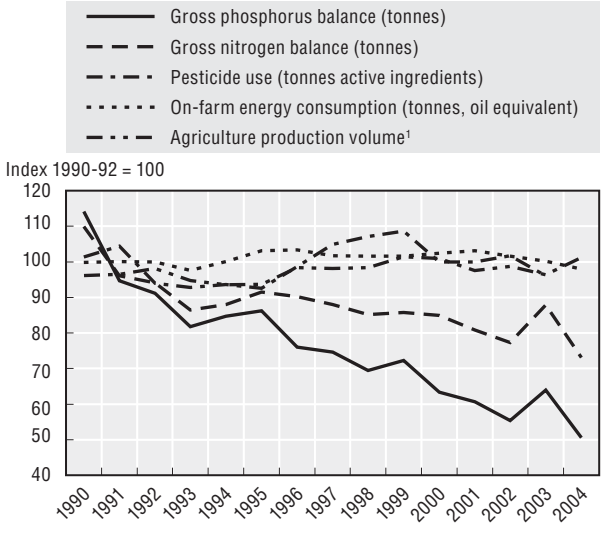
Variable	Unit		European Union 15	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	102	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–7 662	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	83	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	10	10
Agricultural pesticide use	Tonnes	1990-92 to 2001-03	–12 144	–46 762
Direct on-farm energy consumption	000 tonnes of oil equivalent	1990-92 to 2002-04	–640	+1 997
Agricultural water use	Million m^3	1990-92 to 2001-03	+3 916	+8 102
Irrigation water application rates	Megalitres/ha of irrigated land	2001-03	6.1	8.4
Agricultural ammonia emissions	000 tonnes	1990-92 to 2001-03	–249	+115
Agricultural greenhouse gas emissions	000 tonnes CO_2 equivalent	1990-92 to 2002-04	–30 611	–30 462

n.a.: Data not available. Zero equals value between –0.5% to < +0.5%.

1. For agricultural water use, pesticide use, irrigation water application rates, and agricultural ammonia emissions the % change is over the period 1990-92 to 2001-03.
2. Percentage change in nitrogen and phosphorus balances in tonnes.

Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

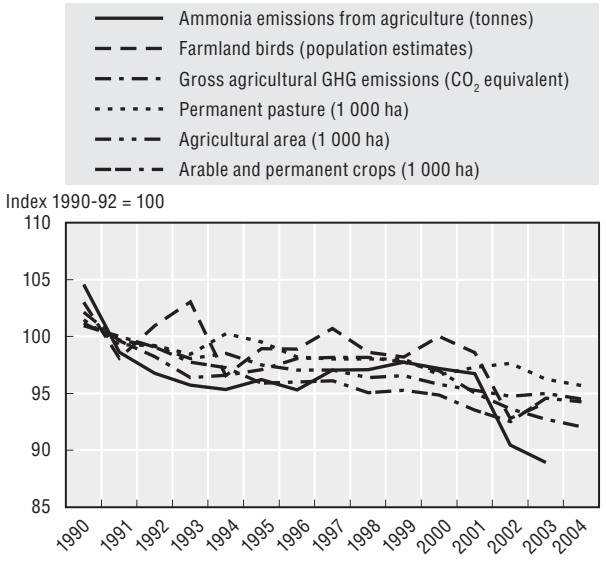
Figure 3.31.3. **Agri-environmental trends, EU15**



1. Index 1999-2001 = 100.

Source: OECD Secretariat.

Figure 3.31.4. **Agri-environmental trends, EU15**



Source: OECD Secretariat.

StatLink http://dx.doi.org/10.1787/301361278285

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Chapter 4

Using Agri-environmental Indicators for Policy Analysis

Agri-environmental Indicators (AEIs) can contribute to the needs of policy makers and other users in a number of ways examined in this chapter. A brief overview is provided in Section 4.1 of recent developments in domestic agricultural support; agri-environmental policy measures; and multilateral environmental agreements affecting agriculture, in particular, drawing a link to the material included in the country sections of Chapter 3. Section 4.2 discusses how selected OECD countries and international organisations, including OECD, are using AEIs as part of their toolkit to report on the environmental performance of agriculture. A selective literature review in Section 4.3 examines how AEIs are being used by OECD member governments, the OECD and other international governmental organisations, and other researchers, in analysing the linkages between the effects of agricultural and environmental policies on environment outcomes. Finally, Section 4.4 highlights where key gaps exist in terms of knowledge, methodologies, and data which are limiting the use of AEIs for reporting the state and trends of environmental conditions in agriculture and as a tool in policy analysis.

4.1. Policy context to OECD agri-environmental performance

Policies are identified in this report as a key driving force in determining the environmental performance of agriculture, as shown in the Driving Force-State-Response Framework (Figure II.1 in the *Background and Scope of the Report*, Section 2). Three broad categories of policies can act to intensify or reduce the pressure of agricultural activities on the environment:

1. ***Agricultural policies***, which have objectives other than environmental ones, such as market price support, output payments and input subsidies (*e.g.* for energy and water), which can provide incentives to intensify and increase production and thus, exacerbate pressure on the environment. These policies, however, are often accompanied by production constraints, such as production quotas, set-aside land and cross compliance which can act to reduce pressure on the environment.
2. ***Agri-environmental policies***, which are specifically designed to enhance some environmental benefits associated with agriculture or offset the effects of production-linked support.
3. ***Environmental policies***, aimed at specific environmental issues (*e.g.* water pollution) but that can have an effect on agriculture, and which can be either national or international in scope.

OECD agricultural policies resulted in 2004 in the value of support to producers as a whole at an estimated USD 279 billion or EUR 226 billion (OECD, 2005a). The level of support, as measured by the Producer Support Estimate (PSE), accounted for 30% of farm receipts in 2002-04 compared to 37% in 1986-88. Support continues to vary widely across countries and commodities. Governments are gradually changing the way in which support is provided, away from the most production and trade distorting measures like import tariffs and export subsidies, and towards payments based on areas farmed and historical entitlements.

In response to the growing attention focused on the effects of agriculture on the environment, ***agri-environmental measures*** have assumed a more prominent role in agricultural policy in OECD countries in the past two decades (Box 4.1 and discussed in greater detail in the country sections of Chapter 3). OECD countries currently address environmental issues in agriculture with a plethora of sometimes overlapping measures, combining elements of direct regulation, economic instruments, education, persuasion

Box 4.1. **Main agri-environmental measures in OECD countries**

European countries and the **United States**, in particular, have substantially increased the use of ***incentive payments*** in the past decade to improve environmental quality in agriculture. Some notable trends include the growing use of payments to support the adoption of less-intensive farming practices; land retirement payments tailored to specific environmental objectives; and transitional payments to assist farmers in implementing structural changes to benefit the environment. In budgetary terms these policies are becoming increasingly significant – for example, total **European Union** expenditure on agri-environmental payments is projected to increase by 68%, from an average of EUR 2.2 billion per annum in the 1994-99 period, to EUR 3.7 billion per annum over the 2000-06 period.

Some countries, including **Australia, Canada** and **New Zealand**, have made widespread use of ***community-based approaches*** to address environmental issues – *e.g.* through supporting collective action to solve environmental problems, variously known as landcare groups or conservation clubs. These approaches tend to take advantage of farmers' self interest in environmental conservation and make use of local expertise in solving environmental problems.

All OECD countries impose ***regulatory requirements*** to address the negative effects of agricultural activities on the environment, ranging from outright prohibitions, to standards and resource-use requirements. In many cases these requirements have been extended or developed over the past fifteen years. An increasing number of regulatory requirements derive from state, provincial, regional or local measures under the framework of national umbrella legislation, in order to accommodate the local nature of many environmental concerns.

There still appears to be only limited application of ***taxes*** and ***charges*** to directly integrate the environmental costs of agricultural activities into farmers' production decisions – particularly compared to the application of such measures in other sectors. This in part reflects the logistical difficulties of applying such measures in agriculture, but may also reflect differences in how property rights are regarded in agriculture compared to other sectors. Taxes and charges on farm inputs are, however, sometimes used. ***Tradable rights*** do not appear to play a significant role in agri-environmental policy, although they are applied in the **Netherlands**, and on a state/regional basis in the **United States** and **Australia**.

Many OECD countries have directed greater attention towards improving the knowledge-base relating to environmental issues in agriculture through increased spending on agri-environmental ***research***, often undertaken in co-operation with the private sector. Generally, greater emphasis has also been placed on communicating information to farmers on environmental issues via ***technical assistance*** and ***extension***, in order to induce voluntary changes in farming practices and on improving environmental outcomes, including through the adoption of low input and organic farming systems.

Source: OECD (2003), *Agricultural Policies in OECD Countries: Monitoring and Evaluation 2003*, Paris, France.

and community involvement (OECD, 2006, 2005b, 2004a, 2004b, 2003a). The key features of the measures currently in place include:

- ***targets or thresholds***, especially for pesticide use, water quality, and ammonia and greenhouse gas emissions;
- ***regulations***, often used to enforce particular farming practices (*e.g.* manure storage), supported by fines and charges for non-compliance;
- ***agri-environmental payments***, which vary considerably across countries as they are variously intended to contribute towards the cost of meeting regulations; compensate for income lost by adopting certain practices; and reward farmers for providing environmental services;
- ***taxes and charges***, the use of which is very limited; and
- ***market-based approaches***, such as tradable permits and voluntary community-based approaches are limited but of growing importance.

Environmental policies, operating at both the national and international scale and usually directed at a specific environmental issue, are also increasingly impacting on the agricultural sector. At the national level environmental policies that most commonly impact agriculture concern energy use, water pollution, use of water resources, air pollution from ammonia, ozone depletion, climate change and biodiversity. These policies are examined in greater detail in the country sections of Chapter 3. Multilateral environmental initiatives, and in many cases their respective reporting requirements, are also having an impact on agriculture (Box 4.2).

4.2. Tracking agri-environmental performance

4.2.1. Evolution of Agri-environmental Indicators to track sustainable development

Agri-environmental indicators (AEIs) have evolved as part of a long history of establishing socio-economic indicators and statistical databases to meet demands by the public and policy decision makers for better information on economic performance and social trends (Bonnen, 1997). The first efforts at developing environmental indicators for OECD countries came during the early monitoring of industrial pollution during the 1960s and 1970s. But it was not until the publication of the Brundtland Report (1987) *Our Common Future* in 1987 and the 1992 United Nations "Earth Summit" at Rio de Janeiro (United Nations, 1993) that development of sustainable development indicators began, leading to the completion of the UN's Commission on Sustainable Development Indicators set in 2001 (UNCSD, 2001).

By the time of the World Summit on Sustainable Development in Johannesburg in 2002 (United Nations, 2002), governments had introduced a range of new policy measures in an attempt to steer their economies along a sustainable path and in so doing began to use indicators to help assess the effectiveness and efficiency of these policies and in the reporting requirements of multilateral environmental protocols (Hardi and Zdan, 1997; Hass *et al.*, 2002; Lawn, 2004).

While AEIs have been developed as part of the wider effort to extend environmental reporting and broader sustainable development indicators, they have also been developed by national and international agencies in response to growing public interest in environmental issues and because of the introduction of agri-environmental policies in most OECD countries over the 1990s as described in Section 4.1 (Brouwer and Crabtree, 1999; OECD, 2001; 1999).

Box 4.2. **Selected international and regional environmental agreements relevant to agriculture**[1]

Issue	International agreements[2]	Regional agreements[2]
Nutrients, pesticides, water	• Convention on the Protection and Use of Transboundary Watercourses and International Lakes, *www.unece.org/env/water/*.	• Convention for the Prevention of Marine Environment of the North-East Atlantic (OSPAR Convention), *www.ospar.org/*. • Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM Convention), *www.helcom.fi/home*. • Agreement on International Commission for Protection of the Elbe, Danube and Odra, *www.internationalwaterlaw.org/europe.html*. • EU Directives: Water Framework, Nitrate, and Drinking Water, *http://ec.europa.eu/environment/water*. • Convention on the Cooperation for the Protection and Sustainable Use of Waters of Portugal and Spain River Basins. • North American Agreement on Environmental Cooperation (Canada, Mexico, United States), *www.cec.org/*. • Great Lakes Water Quality Agreement (Canada, United States), *www.ijc.org/*. • International Boundary and Water Commission (Mexico, United States), *www.ibwc.state.gov/*.
Soil	• UN Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, *www.unccd.int/*.	• EU Directive establishing a framework for protection of soil (proposal), *http://ec.europa.eu/environment/soil*.
Air	• UN Convention on Long-range Transboundary Air Pollution (Gothenburg Protocol), *www.unece.org/env/lrtap*. • *Montreal Protocol* on Substances that Deplete the Ozone Layer (related to the use of the methyl bromide pesticide), *www.unep.org/ozone/*. • UN Framework Convention on Climate Change (*Kyoto Protocol*), *www.unfccc.org/*.	
Biodiversity, landscape	• Convention on the Conservation of Migratory Species of Wild Animals, *www.cms.int/*. • Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), *www.cites.org/*. • Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention), *www.ramsar.org/*. • Convention on Biological Diversity, *www.biodiv.org/*. • Convention Concerning the Protection of the World Cultural and Natural Heritage, *www.unesco.org/whc/*.	• EU Habitat and Wild Birds Directive, *http://ec.europa.eu/environment/nature/*. • European Landscape Convention, *www.coe.int/t/e/cultural_co-operation/environment/landscape*. • Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), *www.coe.int/t/e/cultural_co-operation/environment/nature_and_biological_diversity/nature_protection/*. • Canada-United States Migratory Birds Convention, *www.fws.gov/migratorybirds/*. • Carpathian Convention, *www.carpathianconvention.org*.

1. For other international and regional agreements related to the environment, see the Environmental Treaties and Resource Indicators (ENTRI) website: *http://sedac.ciesin.columbia.edu/entri/*.
2. For each listed agreement, the respective website is indicated.

Source: OECD Secretariat.

Much of the initial effort in evolving AEIs has been to identify appropriate indicators, and establish data sets to track the state and trends of environmental conditions in agriculture. Progress has been made in this initial phase of AEI development across national government agencies (Section 4.2.2); international governmental organisations, including the OECD (Section 4.2.3); and non-governmental organisations and the private sector (Section 4.2.4). This body of work has provided the foundation to begin using AEIs as a tool in policy monitoring and evaluation to better understand the linkages between policies and agri-environmental outcomes (Section 4.3).

4.2.2. Tracking national agri-environmental performance

Many OECD countries have produced studies using AEIs to report on the state and trends of the environmental performance of agriculture, especially since the early 1990s (Baldock, 1999). This section provides a brief selective guide to these reports, highlighting where efforts have been made by countries to link agri-environmental reporting to policy developments. A more detailed survey of national efforts to track the environmental performance of agriculture is provided in each of the country sections in Chapter 3.

Australia

The National Land and Water Resources Audit (NLWRA) in Australia is periodically updating on the status of natural resources of the country and in 2002 presented a series of initial national assessments of resources used and affected by agriculture (NLWRA, 2002). The audit describes socio-economic and environmental issues of the farming community and examines in some detail soil and water resource degradation issues using regional economic assessments and case studies. The Audit quantified the natural resource base used by agriculture as well as agricultural outputs derived from these natural resources and in so doing established a baseline for agri-environmental policy-making in the country.

As an extension of the work of the NLWRA, in 2004 the Natural Resource Management Ministerial Council (2004) established and agreed a set of national resource (agri-environmental) condition indicators. The agreed indicators relate to: land affected by salinity (groundwater and surface land area); soil conditions, including acidification, wind erosion, water erosion and soil carbon content; water quality, including nutrients (nitrogen and phosphorus) and sediment in the aquatic ecosystem; and other related indicators not specific to agriculture on river, wetland and estuarine conditions; native vegetation cover; and invasive species.

Environmental monitoring data of relevance to agriculture is also collected and analysed by the Australian Bureau of Statistics (ABS). An ABS report in 2003 placed monetary values for the first time on some of the environmental conditions affecting agriculture, stating that in 2000, Australia had around 3 million hectares of saline soils, 109 million hectares of sodic soils and 21 million hectares of acidic soils (Trewin, 2003). These three types of degraded soils were estimated to cost Australian agriculture AUD 187 million, AUD 1 035 million and AUS 1 585 million respectively in annual production losses.

Canada

Agriculture and Agri-Food Canada published a national report on agri-environmental indicators in 2000 (McRae *et al*., 2000) and have updated this in 2005 (Lefebvre *et al*., 2005). The agri-environmental indicators were developed by an interdisciplinary team of specialists from the Department's Research Branch and Strategic Policy Branch. Where possible, data are presented spatially utilising a national soil landscape map base linked to variables derived from the Census of Agriculture, and often report on risk, based on the combination of known soil, climate and cropping information for a given landscape. Farm management and crop information come from the Canadian Census of Agriculture and Statistics Canada surveys. The utilisation of risk indicators in the absence of site-specific monitoring data characterise the Canadian agri-environmental reports.

Finland

AEIs have been developed by Agri-Food Research for the Finnish Ministry of Agriculture and Forestry (Yli-Viikari *et al*., 2002) that cover a wide range of issues including soil quality, nitrogen balances at national and regional watershed scales, greenhouse gas emissions from agriculture (utilizing IPCC methodology) and ammonia emissions. For the AEIs covering biodiversity, they include the genetic diversity in domestic plant and animal breeds, threatened species, bird populations and habitat use, butterflies and weeds. Structural landscape indicators have also been defined to include landscape openness, edge density of fields and agricultural land use trends. In addition to this effort, Statistics Finland (2004) publish annually a series of indicators on natural resource and environmental conditions. This includes coverage of agriculture, including impacts of nutrient run-off and regional information on tillage operations and pesticides.

France

In France, the Institut Français de l'Environnement (IFEN) has a mandate to identify the legislative and regulatory targets currently in force and to devise suitable indicators to measure performance against the targets (IFEN, 2000). France conducts environmental planning on administrative units based on the spatial hierarchy of Regions, Départements and Communes. This has resulted in various *ad hoc* studies related to AEIs but regularly published data series are lacking, except the frequently published series on pesticides in water (IFEN, 2006).

Italy

The National Institute of Agricultural Economics published a national report aimed at measuring the progress of Italian agriculture towards sustainability (INEA, 2004). The volume presents a set of *agro-sustainability* indicators allowing for simultaneous assessment of social, economic and environmental issues. Relationships with the other sectors of the economic system, and the complex articulation (and differentiation) at the territorial level with special attention to rural areas are taken into account.

The *economic dimension* mainly refers to the efficient use of resources, competitiveness, and viability of the agricultural sector. The *social dimension* refers to equity meant as "equal opportunity", both territorially (between rural and non-rural areas) and sector-wise (between agriculture and other economic sectors), and also between men and women in the sector. The *environmental dimension* concerns management and conservation of natural resources. The analysis is based on a list of environmental objectives of policy relevance: protection of water resources (qualitative and quantitative issues) and soil; combating climate change; protection of landscape; and biodiversity conservation.

The complexity of the relationships among the three dimensions has been analysed through the *dashboard of sustainability*. Using the metaphor of a vehicle's instrument panel in terms of sustainability, the "dashboard" method provides an efficient representation of the complexity of the issue of sustainability and of the impossibility of resulting in a universal assessment. To verify the sustainability of Italian agriculture over time, this report will be updated periodically.

Switzerland

Switzerland is developing a set of indicators allowing for an assessment of sustainability of agriculture under its three pillars, economy, social and ecology. For the environmental part, the Swiss Federal Office for Agriculture implemented in 2002 the first stage of designing and implementing a set of agri-environmental indicators with the full set planned to be operational (methodology and data) in a first step by 2008 (Swiss Federal Research Station for Agroecology and Agriculture, 2003). The set includes 3 types of indicators covering: farming practices; agricultural process (risk indicators); and environmental state, including various environmental themes such as nitrogen, phosphorus, water, soil, energy, climate and biodiversity. Indicators are established by a group of experts, with work in progress determining what are the most relevant methodology and data for the calculation of the indicators. The indicators already established are regularly reported by the government (Office fédéral de l'agriculture, 2005). In addition, the Swiss Federal Office for the Environment has a longer track record in overall environmental monitoring. It is constructing an Eco-Fauna Database, which is a matrix of the habitat and other requirements for nearly 3 000 species of fauna, *e.g.* mammals, butterflies, birds (Walter and Schneider, 2003) as well as networks for observation of water, air and soil quality. These environmental monitoring programmes are also being integrated into agri-environmental policy evaluation (Badertscher, 2005).

United Kingdom

Original work on sustainable development indicators relating to agriculture in the United Kingdom came from the Department of Environment's 1996 report (Indicators Working Group, 1996), that led in 2000 to publication of a full suite of AEIs (MAFF, 2000). These included certain economic indicators (agricultural support estimates, income and employment), input use (fertilisers, energy and pesticides) and resource use (water, soil organic matter, land use and heavy metals). Indicators were presented using time series data and trends for a 25-year period up until 1998. There is now an annual updating of this work providing key environmental indicators, which also include cover agriculture, such as the farmland bird index, agricultural land use changes, and water pollution (DEFRA, 2005).

United States

The Economic Research Service (ERS) of the United States Department of Agriculture (USDA) has prepared a series of reports starting in 1994 up to 2006 which have identified environmental trends in land, water, and biological resources as well as agricultural input use (nutrients, pesticides, seed and machinery) (USDA, 2006). These reports go beyond traditional "state of environment" reports in that monetary values are linked to physical units, (water and soil) in selected case studies. National scale maps illustrate resource conditions generally at one point in time such that trends are not easily established. Through the use of literature reviews and summaries of economic studies, the reports bring together a vast store of information to the topic of agriculture and the environment.

Two key data sources for the ERS AEI reports and other agri-environmental policy analysis in the United States are the USDA's *National Resources Inventory* (NRI) and the US Geological Survey (USGS) *National Water Quality Assessment* (NAWQA). The NRI programme, conducted by the Natural Resources Conservation Service formerly the Soil Conservation Service, has been collecting natural resources data since the 1930s. The current inventory (*www.nrcs.usda.gov/technical/NRI/*), which is updated regularly, is a longitudinal survey of

soil, water and related resources designed to assess condition and trends every five years on the non-federal lands of the United States (Goebel, 1998). The NRI has evolved over the decades as resource issues have changed in an effort to better assess soil conservation, natural resource health, and other environmental issues.

Under the NAWQA, scientists since 1991 have been collecting and analysing data and information in more than 50 major river basins and aquifers across the US. The goal is to develop long-term consistent and comparable information on streams, groundwater, and aquatic ecosystems, including in predominantly agricultural areas, to support sound management and policy decisions. The NAWQA programme is designed to answer the following questions (*http://water.usgs.gov/nawqa/index.html*):

1. What is the condition of our nation's streams and groundwater?
2. How are these conditions changing over time?
3. How do natural features and human activities affect these conditions?

The National Research Council (2000) formed a *Committee to Evaluate Indicators for Monitoring Aquatic and Terrestrial Environments* which reviewed indicator development and their relevance to policy makers. They observed that to develop and implement sound policies, data are needed that capture the essence of the dynamics of environmental systems and that these data then need to be incorporated into indicator calculations. The report identifies three families of indicators and their relation to agro-ecosystems:

1. Ecosystem extent and status (land cover, land use);
2. Ecological capital (species diversity, soil organic matter, nutrient run-off);
3. Ecosystem function (net primary production, carbon balance, nutrient balance).

4.2.3. International reporting on environmental conditions in agriculture

OECD Secretariat

The main OECD work on agri-environmental indicators has been published through the three volumes of the series *Environmental Indicators for Agriculture*, already discussed in the *Background and scope of the Report,* Section II (OECD, 2001a; 1999; 1997). This Volume in the series has also been supported by seven OECD Agri-environmental Indicator Expert Meetings on different indicator themes from which the Proceedings have been published (Box II.1, *Background and Scope of the Report*, Section 2). The AEI work has also draw from the OECD's Environment Directorate's regular publication of the series *Environmental Data Compendium* and related OECD *Environmental Indicators: Development, Measurement and Use* (OECD, 2003b). This work is supported by a regular environmental data questionnaire to OECD member countries, which also collects some data relevant to agriculture, such as on pesticide and water use. Both the AEI work and that of environmental indicators has also been part of a broader and ongoing effort by OECD to examine sustainable development. The analysis has included focus on frameworks to measure sustainable development (OECD, 2000a) and defining indicators to measure progress toward sustainable development (OECD, 2000b).

European Environment Agency and European Commission

A joint project co-sponsored by the European Commission (Directorate-General [D-G)] for Environment and D-G for Agriculture entitled *Indicator Reporting on the Integration of Environmental Concerns into Agricultural Policy* (IRENA) published a comprehensive report on

agri-environmental indicators for the EU15 (EEA and European Commission, 2006). The analyses utilised, wherever possible, a spatial framework of the EU Nomenclature of Territorial Units (NUTS) to report on many indicators in map form at national and sub-national levels. Data are also drawn from the various surveys of Eurostat (the EU Statistical Office), and both IRENA and Eurostat share data and some indicator development with OECD, most notably for nutrient balances (Chapter 1). The report builds on 40 agri-environmental indicators reporting on farm trends, water quality, land use, farm management, soil quality, climate change, air quality, biodiversity and landscape. Each indicator is evaluated for its usefulness and feasibility of on-going reporting, and IRENA covers the previous EU15 member states and the period 1990 and 2000. The IRENA operation integrates indicators with specific policy targets and environmental regulations or standards (EEA, 2006).

Building on an earlier FAO and UNCCD projects on defining environmental indicators related to desertification (FAO, 2003; Florke and Alcamo, 2004), the EU's DG-Research has funded work on desertification indicators for Mediterranean Europe (Brandt *et al.*, 2005). This extends the IRENA agri-environmental indicators on soil and water to address these specific issues in target regions of four EU15 countries (**Greece, Italy, Portugal** and **Spain**).

United Nations and UN agencies (FAO, UNEP)

The United Nations Commission on Sustainable Development (UNCSD) published in 2001 a report on sustainable development indicators that has acted as a guide and building block in the international effort to define and revise environmental indicators (UNCSD, 2001). The indicators under the land theme in the CSD framework focus on the key sub-themes of agriculture, forests, desertification, and urbanisation. Indicators specific to agriculture are limited to the national area of agricultural land use, the annual use of fertilisers, and the annual use of pesticides. Indicators are calculated largely from existing FAO databases of aggregated national data, and are expected to be revised in 2006.

UN reports on environmental indicators tend to be at highly aggregated levels and cover all UN member countries. Examples of this level of reporting include the United Nations Environment Programme (UNEP) ***Global Environmental Outlook*** series (UNEP, 2002) and more specific reviews, such as the integrated assessment handbook of agriculture and trade (UNEP, 2005). They tend not to provide the detail or focus of AEIs developed by OECD member countries. However, the recent ***Millennium Ecosystem Assessment*** project is a major research undertaking that documents scale and status of global agriculture and presents some challenging conclusions (Millennium Ecosystem Assessment, 2005).

The ***Land Quality Index*** programme was a joint initiative of FAO, UNDP, UNEP and the World Bank (FAO, 1997) that developed a set of land quality indicators aimed at assisting planners and policy-makers, particularly in developing countries, to make better use of their existing information on land quality and to promote more systematic data and information collection. This was followed by the production of a handbook (FAO, 2002) on the collection of data and compilation of indices. More recent FAO work has focused on desertification indicators (FAO, 2003). The Land Degradation Assessment in Drylands (LADA) project was designed to strengthen support to combat land degradation in response to the need identified by the UN Convention to Combat Desertification (UNCCD). Various indicators of potential use to LADA include indicators on soil moisture, soil depth and productivity, organic carbon, nutrient balance, erosion (including wind and water erosion), biodiversity, accumulation of salts, waterlogging, land use and cover change with application to some OECD Mediterranean countries.

World Bank

In the context of the World Bank's annual *World Development Report*, a subset of environmental indicators is also regularly published. These indicators have a global country coverage, with a sub-section of indicators related to agriculture. However, the agri-environmental indicators are highly aggregated covering only land area, irrigated land area, fertiliser consumption, agricultural water use, food production index and population density (World Bank, 2004).

North American Free Trade Agreement – Commission for Environmental Co-operation (CEC)

Agriculture is covered by the CEC in its *State of the Environment* report (CEC, 2001). Only broad summary statistics of land area, pesticide use, number and size of farms are presented, and no indicators as such were used. However, the CEC has published a much more thorough evaluation of policies and programmes within the NAFTA partnership (CEC, 2003). This report discussed present and future techniques for assessing environmental conditions. It concluded that trend analysis, such as is used in the OECD AEI programme, can be helpful to policy makers needing to understand what has happened in the past and what is happening now. They concluded that it is often less successful as a basis for predicting what will happen in the future. This is an important consideration if one objective of environmental policy is to take preventive action to limit environmental challenges before they become severe and widespread.

Other international governmental organisations

A number of other international governmental organisations are also active in the field of environmental monitoring, usually in the context as Secretariats to International Environmental Agreements (Box 4.2). This Volume has drawn on this work and co-operated closely with the UN Economic Commission for Europe (UNECE) for data on agricultural ammonia emissions (Section 1.7.1, Chapter 1); the UNEP for data related to agricultural methyl bromide use (Section 1.7.2); and the UNFCCC as regards agricultural greenhouse gas emissions (Section 1.7.3). In addition, the International Energy Agency maintains an energy consumption database, which has been drawn on for the energy Section 1.4, in Chapter 1.

4.2.4. Non-governmental organisations (NGOs)

The published inventories of ***BirdLife International*** covering bird population estimates, trends and conservation status (BirdLife International, 2004) and related Important Bird Area summaries (Heath and Evans, 2000) have become accepted as suitable data sources for farmland biodiversity indicators by an increasing number of OECD countries, such as the UK for example (DEFRA, 2005) and in this Volume (Section 1.8, Chapter 1). Birds are a well-studied species and thus have considerable utility in providing information on the overall health of the environment, including farmland habitats. The use of data collected world wide by a network of skilled volunteers is unique and efforts are underway to further enhance the efficiency of data capture and handling of bird observations that could lead to extending the use of bird census information in indicator reporting to other countries in the future (Roberts *et al.*, 2005).

The ***World Wide Fund for Nature*** (WWF) uses two main indicators in its *Living Planet Report* series to measure the world's progress on sustainable development and biodiversity conservation (WWF, 2004). The *Living Planet Index* measures overall trends in populations of wild vertebrate species around the world. The second is the *Ecological Footprint* that is a

measure of environmental consumption. The Ecological Footprint measures a community's use of natural resources and represents the bio-productive area necessary to both produce the resources (goods, services, energy, food) consumed by a population and absorb the waste it produces (Wackernagel and Rees, 1996). Since people use resources from all over the world, footprints add up the extent of these uses and express them on an area basis (Wackernagel *et al*., 2004), such as the recent report by the WWF on the *Ecological Footprint of Europe* (WWF, 2005).

The ***International Food Policy Research*** (IFPRI) and ***World Resources Institutes*** (WRI) published a pilot analysis of global agroecosystems (Wood *et al*., 2000). They reported a series of environmental (soil, water, air and land cover) impacts occurring from global agriculture and highlighted the double pressure on agricultural land of increasing food production while continuing to provide environmental goods and services. Data from this report has been used in the Millennium report of UNCSD (Section 4.2.3). The WRI also publish annually a series of global environmental data by country with some information on agriculture, but highly aggregated and largely drawn from other sources such as the FAO and the World Bank (WRI, 2005). On an *ad hoc* basis IFPRI publishes studies that analyse world agriculture and the status or outlook for supporting natural resources, such as soil and water (Rosegrant *et al*., 2001).

The US-based ***Heinz Center*** report *The State of the Nation's Ecosystems* was a collaborative effort between government, private sector and environmental organisations and academia (Heinz Center, 2002; 2006). A part of the report examined farmlands using a total of 18 indicators, however, only 9 of the 18 indicators specified had full data available and only 5 of these 9 had long enough data series to assess trends. Specified soil indicators include soil organic carbon content, wind and water erosion and salinity, comparable to the OECD soil quality indicators. The introduction to the report states, "we cannot know whether out current environmental policies and practices are sound, and we cannot make new policy with confidence, without a set of generally accepted measures of fundamental properties of the environment".

The ***European Centre for Nature Conservation*** (ECNC) made a pre-IRENA (Section 4.2.3) attempt at defining indicators for Europe, which was financed under the European Commission research programme (Wascher, 2000). The study focused on issues and methods but did not report performance, other than through illustrative example. Subsequent indicator reporting by the ECNC took the form of risk assessment (Delbaere and Serradilla, 2004).

4.3. Using Agri-environmental Indicators for policy analysis

This section provides a selective review of the literature in terms of providing illustrative examples of the use of AEIs for policy monitoring and evaluation. There are a number of ways in which to structure such a literature review, for example, in terms of policy categories and types (*e.g*. agricultural policies, agri-environmental measures, payments, taxes, etc., as in Section 4.1) or by environmental themes, such as those in Chapter 1 of this report (*e.g*. soil, water, air, etc.). The choice of structure to organise this section, however, is made in terms of the institutions that have prepared reports, including: OECD member country governments (Section 4.3.1); the OECD and other international governmental organisations (Section 4.3.2) and other research studies (Section 4.3.3), largely from academic research centres.

4.3.1. OECD member countries

Australia

In an examination of community based programmes in Australia, Lee and Wood (2005) examined the establishment of regionally developed indicators to monitor progress against environmental and natural resource targets. Indicators have been set at the national (Federal) policy level but need to be applied at the regional (State) level. Those with general applicability across a range of scales are indicators that relate to extent (*i.e.* the extent of native vegetation, extent of salinity, extent of soil erosion). More challenging is the application of indicators of resource conditions (*i.e.* the conditions of native vegetation, soil salinity, etc.), the setting of baseline conditions, and general data availability. Ultimately this leads to the preparation of a report card that will provide a mechanism for regular national reporting against targets for resource condition using an agreed set of indicators and consistent framework for reporting at regional, state and national levels. There are indicators for each programme area including land salinity, soil condition, native vegetation community integrity, inland aquatic ecosystems, coastal habitat, nutrients in aquatic environments, surface water salinity, and ecologically significant invasive species (Natural Resource Management Ministerial Council, 2004).

Canada

Canada uses an integrated modelling capacity linking its Canadian Regional Agricultural Model (CRAM), an economic model used for policy analysis, to science based agri-environmental indicators in order to understand how changes to agricultural policies and programs affect the sector's economic and environmental outcomes, and evaluate future plans. This multidisciplinary approach has recently been directed towards the assessment of possible greenhouse gas (GHG) mitigation strategies for agriculture (Junkins, 2005) and to support the selection of quantitative provincial environmental outcome targets under the *Agricultural Policy Framework* (APF). The APF analysis assessed the impacts of adopting a suite of beneficial management practices (BMPs) for agricultural production on a number of environmental indicators including GHG emissions, soil erosion from wind and water, residual nitrogen and the risk of water contamination from nitrogen, change in soil organic carbon, and wildlife habitat (Heigh *et al.*, 2005). MacGregor *et al.* (2001), outlined the data needs to support this integrated economic and environmental modelling system which is being used for policy assessment and development. An earlier application of integrated analysis involved a comprehensive environmental impact assessment of the *Canadian Federal-Provincial Crop Insurance Program* (AAFC, 1998). The study used CRAM to estimate changes in producer decisions attributable to crop insurance and linked the results to indicator algorithms to assess changes in soil erosion from wind and water. The crop insurance study assessed other environmental issues such as salinisation and wildlife habitat by linking CRAM results to GIS maps of environmental risks.

Denmark

A largely regulatory approach has been taken in Denmark to reduce water pollution by agriculture. To help evaluate the effectiveness of these regulations a set of national agri-environmental indicators were formulated, including nitrogen balances, nitrogen efficiency and nitrate leaching set within the Driving Force-Pressure-State-Impacts-Responses (DPSIR) framework. The indicators reveal reductions in aquatic system nitrogen concentrations, although biological response is still rather weak due to large annual variations and ecosystem complexity (Mikkelsen *et al.*, 2005).

Germany

Agri-environmental payment for the conversion to organic farming, have been examined in Germany, comparing farms with and without support (Osterburg, 2005). Payments were designed to help reduce nitrogen surpluses and maintain biodiversity on farmland. Data from farm accounts (changes in land use and input intensity) were used to evaluate the effectiveness of this policy approach, with changes in nitrogen balances used as one of the measures of the effectiveness of policy.

New Zealand

New Zealand uses indicators and other quantitative data extensively in reporting agri-environmental policy and climate change policies and in preparing New Zealand's Greenhouse Gas Inventory. Land and water data are used widely in forestry policy and management, analysis of soil quality and erosion, and in water policy, which needs indicators of improvement or deterioration in water quality. A *Linked Indicator Project* was recently instituted, which examines a range of economic, social, cultural and environmental measures significant to communities and their well-being. These indicators will provide information to support the monitoring and reporting requirements of local authorities, and will cover both urban and rural councils. The project aims to include measures of: energy use, water use, land use and cover, economic and industry activity, as well as a range of standard of living indicators.

Other work addresses environmental sustainability and natural resource accounting (environment accounts). Land and water information collected within the Agricultural Statistics programme includes areas in agricultural production, land use on farms and forestry blocks, areas of standing vegetation and crop residue burnt, quantities of nitrogen-based and other fertilisers applied, areas of land under an irrigation system and the areas actually irrigated, and the agricultural activity carried out on irrigated land.

Proposals for future activities include the collection of a wider range of additional agri-environmental information, including: water quality; irrigation methods; agricultural use of groundwater; frost protection; use of pesticides; herbicides and other agrichemicals; effluent and waste disposal; tillage practices; intensification of land; land use intentions; sustainable production and sustainable farming practices; agricultural impacts on the environment; effluent and toxic waste management; soil information and erosion; and fencing.

Norway

A pesticide tax was introduced in Norway in 1999 to reduce pesticide use with the aim of lowering risks of pesticides to human health and the environment. As a follow-up, indicators were developed to describe the trends of human health and environmental risks associated with pesticide use (Spikkerud 2005; and Section 1.3.2, Chapter 1). Calculations were based on sales data and not on actual use data.

Switzerland

Switzerland has established a set of AEIs specifically to aid policy evaluation, including indicators related to nutrient balances, energy efficiency, GHG emissions, risk of pesticide contamination of groundwater, risk of erosion, and biodiversity indicators (such as diversity of wild species and diversity of habitats on farmland). Indicators are also used to demonstrate whether or not environmental targets for reduced nitrogen and

phosphorous surpluses, ammonia emissions, lower pesticide use, nitrate content of water and habitat diversity have been reached.

Under the quadrennial revisions of the agricultural policy, agri-environmental indicators are variously used to analyse whether the agri-environmental objectives were achieved (objectives set most often on the basis of *ex ante* analysis of indicators) and, if that has not been the case, they are used to redirect or adapt agricultural policy measures. For example in 2006, the objectives for nitrogen and energy were not achieved, hence the Swiss Federal Office for Agriculture proposed that the Swiss government launch a new programme: sustainable use of natural resources. Furthermore, ecological payments for ecological compensation, animal welfare payments and cross-compliance were evaluated using agri-environmental indicators and a variety of other tools and methods (Badertscher, 2005) and are being revised following the results of these evaluations.

United States

In the United States an environmental benefits index (EBI) has been established to rank the impacts of the *Conservation Reserve Program* (CRP) on the provision of agri-environmental goods and services (Claassen *et al.*, 2001; Hellerstein, 2005). Farmers bid to retire land from production and the USDA has used the EBI to judge bids. The EBI balances expected environmental benefits against costs of retiring land, with points scored for wildlife habitat creation, water quality benefits from reduced erosion, run-off and leaching, reduced wind erosion and emissions of GHGs. An extension of the EBI was developed by Cattaneo *et al.* (2005) in terms of an Aggregate Environmental Index (AEI), which is similar to the EBI and used by the US Department of Agriculture (USDA) to assess CRP contracts. The AEI takes into consideration nine resource concerns: nitrogen into surface waters and subsurface waters, phosphorus in surface waters, pesticides into surface and ground waters, sediment into surface waters, wind erosion, carbon loss into the atmosphere and long-term soil productivity.

The effectiveness of the CRP in reducing soil erosion was also examined by Claassen (2005). During the time of the programme's existence, beginning in 1985 and up until 1997, soil erosion was reduced in the US by nearly 40%. However, in his analysis, he concludes that only a quarter of that can be attributed to conservation compliance, the rest coming from technological and market changes. This evaluation drew on the Natural Resource Inventory (NRI), as described in Section 4.2.2. From these data, together with those from the Agricultural Resource Management Survey (ARMS) and using the universal soil loss equation (USLE), changes in soil erosion by water over time were calculated.

A further USDA study (Aillery *et al.*, 2005) used a modelling mass balance approach to assess policy impacts of manure management on US farms. Modelling was focused at the farm and regional scales, and trade-offs between reduced ammonia emissions and increased nitrogen run-off into water bodies were examined as they relate to meeting regulations under the US *Clean Water Act* and *Clean Air Act*.

4.3.2. International governmental organisations

OECD Secretariat

The OECD Secretariat has used AEIs in three broad types of policy analysis:

1. statistical correlation;
2. outlook studies, involving the use of projection models; and,
3. in economic modelling of the linkages between policies and agri-environmental outcomes.

The use of AEIs in policy analysis by using statistical correlation of cause and effect has been most extensively used by the OECD in its country report series *Environmental Performance Reviews*, especially where agriculture has been highlighted as a special theme (*e.g.* **New Zealand**, see OECD, 2007a). Changes in nutrient balances and pesticide use, for example, have been correlated to relevant policy changes where these have occurred. A similar approach was taken in the case of the recent OECD series of country *Economic Surveys*, by drawing on the nitrogen balances in assessing policies to address water pollution (OECD, 2004c). A further example of using the nitrogen balance indicator was the OECD study that examined decoupling of environmental pressure from economic growth, including decoupling of resource use from agricultural production growth (OECD, 2002).

In a paper on the instrument mixes used to address non-point sources of water pollution from agriculture (OECD 2007b), a range of indicators are used to assess the effectiveness of various instruments, with case studies from **Denmark**, the **Netherlands** and **UK**. Indicators on fertiliser use, pesticide use, nutrient (N and P) balances are used. In both **Denmark** and the **Netherlands** case studies, detailed nutrient accounting system have been implemented to keep track of, and to control, the application of nutrients. Implementation of tracking systems provides additional information from which agri-environmental indicators can draw.

In terms of ***the use of AEIs in OECD outlook (projection) reports***, the AEIs have been used in the *Agricultural Outlook* (OECD, 2001b) to examine the long-term outlook for agriculture and the environment. In addition, AEIs were drawn on in the first *Environmental Outlook* (OECD, 2001c), and will do so again for the second report for 2008, providing projections to 2030.

The most extensive use of AEIs by OECD has been in economic modelling of the linkages between policies and agri-environmental outcomes. Particularly extensive use of AEIs in modelling various policy scenarios was included in the series of OECD commodity studies (pigs, dairy and arable sectors) Agriculture, Trade and the Environment (OECD, 2006; 2005b; 2004b; 2003a). A literature review into agricultural trade liberalisation impacts in several OECD countries as part of a review of the arable crops sector in agriculture revealed that AEIs were used to help evaluate environmental outcomes (OECD, 2005b). Based on projected changes in cropping mixes and patterns, soil wind and water erosion were reviewed in the **US**, nutrient balances and biodiversity in **Finland**, and nutrient balances in **Austria**. A modified Global Trade Analysis Project (GTAP) model was also used to simulate liberalisation impacts on the arable crops sector with respect to nutrient balances, pesticide use and greenhouse gas emissions indicators. In a parallel study on the dairy sector (OECD, 2004b), agricultural trade liberalisation was again modelled using a modified GTAP model. Production shifts to countries like **New Zealand** and **Australia** were associated with increased GHG emissions and nutrient surpluses that could have impacts on water quality, findings supported in an earlier study and related study which also used AEIs (Saunders and Cagatay, 2004) The OECD Secretariat is further developing its analysis of the linkages between agricultural policies and environmental effects.

Other international governmental organisations

The ***European Union*** has reinforced the monitoring and evaluation of the environmental impacts of the measures included in its rural development policy. The common monitoring and evaluation framework for the rural development programmes 2007-13 foreseen in the EU rural development regulation intends to more

effectively measure the progress in achieving the EU priorities. It will include a set of common indicators (baseline, output, result and impact) including agri-environmental indicators related to the measures concerning the improvement of the environment and the countryside (*e.g.* agri-environmental measures, support for protected *Natura* agriculture and forestry 2000 areas). The agri-environmental indicators will specifically refer to the three EU environmental priority objectives, which are: halting biodiversity decline and the preservation of high nature value farming; achieving the objectives of the *Water Framework Directive*; and mitigating and adapting to climate change (see the EU section in Chapter 3).

The ***European Environment Agency*** has begun to integrate the IRENA set of AEIs into various policy analysis activities (Section 4.2.3). The EEA (2006) report describes the integration of the *European Union's* environmental policy into the *Common Agricultural Policy* (CAP), drawing on the IRENA indicators. Also IRENA indicators were used in the EEA's (2005c) environmental outlook report, which assesses potential environmental consequences of key socio-economic developments in Europe, including agriculture; while another study on the environmental impacts within EU accession countries also utilised IRENA indicators (EEA, 2004).

The ***Secretariat to the Convention of Biological Diversity*** (SCBD, 2005) described the effects of trade liberalisation on agro-biodiversity within the context of the WTO Uruguay Round Agreement on Agriculture (URAA). In this qualitative study it was concluded that… "despite a number of methodological problems in designing agri-environmental programs for the conservation and sustainable use of agricultural biodiversity, mainly related to the lack of reliable and practical agri-biodiversity indicators and to the problem of choosing appropriate benchmarks, it seems that well-targeted, designed and implemented programmes that are based on scientifically sound environmental performance indicators are able to contribute to positive external effects of agricultural production on biodiversity".

The ***United Nations Environment Programme*** (UNEP, 2005) outlines agri-environmental indicators as one of a number of quantitative and semi-quantitative methods to assess environmental impacts of agriculture under a range of policy environments. The report presents a list of possible environmental indicators that could be used covering water quantity and quality, land, biodiversity, energy, air quality, and pesticides.

4.3.3. Research community

There is a growing literature from the research community that is using AEIs for policy analysis. The selective examples highlighted in this section are grouped under two broad headings, first studies that have used AEIs in policy analysis to examine a specific environmental outcome (*e.g.* effects on nutrient balances), and second, those studies that have sought to examine the effects of policy change across a range of environmental outcomes.

In a study of ***nutrient flows*** in agricultural production and international trade, nutrient balance calculations were used to illustrate trends and conditions in both developed and developing countries (Craswell *et al.*, 2004). The study revealed the situation of developed countries with nutrient surpluses and many developing countries with nutrient depletions. Bayliss *et al.*, 2004 also used the nutrient balances indicator as a way of comparing and characterising countries within the **EU** and the **US** and the type of agri-environmental programmes that exist. In comparing US and EU policies they used AEIs indicators to characterise the differences between the two jurisdictions.

While varying ***greenhouse gas emissions*** under different policy scenarios have been modelled for all OECD countries in a number of studies, only a few have done so within the context of examining the impact of agri-environmental policies on GHG emissions. Brito Soares and Ronco (2005) looked at **EU15** countries and equated emissions with the adoption of the Common Agricultural Policy (CAP), with results showing mixed correlations.

Oñate *et al.*, 2000 utilised farm level indicators to evaluate both policy performance and the outcomes of EU agri-environmental policies on ***agricultural landscapes*** in **Denmark** and **Spain**. Using their selected indicators (related to farm land use and farm management), they demonstrated positive and negative impacts on biodiversity values as the result of land use and farm management changes in these two countries.

In using AEIs to examine the effects of policy change across a range of environmental outcomes, a study of the effects of CAP reform in **Austria**, used a series of AEIs to model impacts on methane emissions, carbon storage in soil, nitrate leaching and nitrogen balances, and organic farming (Hofreither *et al.*, 2004). Similarly, the LEI *et al.*, 2003 describe the details of the incorporation of AEIs within the agricultural supply CAPRI model which runs at the regional level in Europe. The following indicator models are linked to CAPRI including nutrient balances, ammonia emissions, water balances and GHG emissions, across a number of policy scenarios including Agenda 2000 and the 2003 CAP Reform Proposal. Using a "Johansen-type" input/output model, the environmental impacts of the post 1992 CAP reforms was performed for a region of **Portugal** (Serrão 1998). The model linked AEIs of the use of fertiliser, pesticides, and energy to stocking density, land use change, crop production intensity and crop cover.

4.4. Knowledge gaps in using Agri-environmental Indicators

Policy decision-making in the environmental and agri-environmental domain is a challenging undertaking (Esty *et al.*, 2006). As highlighted in Chapters 1 to 3 in this report, all OECD countries are addressing a wide range of environmental issues in agriculture. But policy makers face a number of knowledge gaps in particular: incomplete scientific knowledge and data on the effects and timing of policies and agricultural practices on the environment; lack of a monetary numeraire to weigh up and assess the range of environmental impacts from agriculture; and partial knowledge of the impact of the environment on agriculture.

Given the evidence – including in this report – of the growing importance of agri-environmental policies across OECD countries, there is value in developing robust agri-environmental indicators and modelling efforts to improve policy decision making. For AEIs to better serve the needs of policy makers and policy analysis (at both the regional and national levels) as well as the wider public in communicating the state and trends of environmental conditions in agriculture, the knowledge gaps can be viewed in the light of the OECD indicator criteria of policy relevance, analytical soundness, measurability and ease of interpretation:

Policy relevance. There are a set of interrelated agri-environmental policy issues that all OECD countries, although in varying degrees of importance, are addressing:

1. controlling polluting emissions from farming activities (nutrients, pesticides, air emissions);
2. protecting natural resources (quality of soil, water, air, biodiversity);
3. providing ecosystem services (*e.g.* sink for greenhouse gases, flood control); and,

4. changing farm management practices to reduce pollution, protect natural resources and enhance ecosystem provision.

However, some agri-environmental issues that are common to most OECD countries are poorly tracked by the current set of AEIs, notably:

1. farm pesticide and pathogen pollution of water bodies, especially groundwater;
2. soil organic carbon changes in agricultural soils;
3. agricultural use of water resources, especially groundwater;
4. impacts of farming activities on wild species and ecosystems (biodiversity); and the,
5. extent of the adoption of environmental farm management practices and systems.

A key challenge for policy makers is to determine the highest priority investments in monitoring and reporting capacity given limited resources and the large array of "policy relevant" environmental issues faced by governments. This involves moving from physical measures of agricultural impacts on the environment to a set of economic or monetary measures of impacts.

Developing a system of national accounts to reflect the full economic costs and benefits to society of agricultural activities on the environment would enable comparison and evaluation of different environmental issues on a common basis, which is not satisfactorily achieved using physical measures. Hence, it would be possible to compare the relative importance of water pollution with soil erosion or the benefits from biodiversity conservation compared to carbon sequestration in farmed soils.

There are numerous difficulties in measuring the economic costs and benefits of agriculture on the environment; especially deriving estimates of the benefits for which markets frequently do not exist (*e.g.* biodiversity). A number of countries have begun to develop work in this area (Chapter 3). In the **United Kingdom**, for example, the government Department for Environment, Food and Rural Affairs (DEFRA) has research underway (see the reports at: *http://statistics.defra.gov.uk/esg/reports/env.asp*) that seeks to estimate the environmental cost and benefits of farming activities, including the publication of preliminary monetised environmental accounts for the UK agricultural sector (EFTEC and IEEP, 2004).

Analytically sound. A central problem in examining agri-environmental linkages is that it involves a scientific understanding of biophysical relations in the environment and their interaction with farming activities. Many of these relations and interactions are not fully understood at a scientific level, which can make it difficult to guide monitoring activities capable of generating data and indicators useful for policy analysis. There is now a growing effort to better link science with analytical policy tools, particularly through integrating biophysical with economic models, as for example with the ongoing research in **Canada** to develop in an agricultural context integrated economic and environmental models (Junkins, 2005).

As well as improving the underlying scientific understanding of agri-environmental linkages, there is a need at the international level to improve the definitions and methods by which indicators are derived and applied to ensure cross country consistency, which is also recognised more broadly for environmental indicators (Müller and Lenz, 2006). The OECD nutrient balance indicator methodology is an example of progress in this respect, as are the international efforts related to greenhouse gas and ammonia emissions indicators, and the common acceptance among researchers of using the Universal Soil Loss Equation (USLE) to

measure soil erosion (Chapter 1). For other indicators further improvement of the basic rules governing indicator definitions and calculation methodologies would be particularly useful to help policy analysis in the following areas related to primary agriculture:

1. pesticide use and environmental risk indicators;
2. water accounts (surface and groundwater agricultural abstractions and returns);
3. ecosystem indicators, particularly semi-natural habitats on agricultural land; and,
4. farm management, covering management of nutrients, pests, soil, water and biodiversity.

Measurable. Issues relating to data gaps are well recognised in this report and in previous OECD publications on AEIs, and are not further elaborated here (OECD, 2001a; 1999). Most OECD countries are seeking to improve the quality of the spatial and temporal resolution of their datasets used for the calculation of AEIs, not least because these are needed to apply and monitor policy. Other issues relating to improving the quantity and quality of data to calculate AEIs include:

1. ***Integration of databases:*** By seeking ways to integrate different agricultural and environmental databases that are commonly collected on a regular basis across most OECD countries (*i.e.* farm structure surveys, farm account surveys and agri-environmental datasets). For example, frequently farm structure surveys provide data on land cover changes, while farm account surveys may provide information on farm management practices. The integration of databases can provide the opportunity to achieve value added from existing datasets, which is especially important when additional resources for data collection are scarce.
2. ***Coupling indicators:*** By tracing through the cause and effect relationships that is explicit in the *Driving Force-State-Response* framework. For example, as an environmental *driving force* the pesticide use indicator is linked to pesticide risk indicators and the *state* or concentration of pesticides in water bodies. *Responses* to these changes in the state of the environment are revealed through indicators of pest management and environmental farm planning. Coupling indicators can also provide a means to verify the validity of the change in direction of a given indicator. For example, if the nitrogen surplus balance is showing a rising trend then it would be expected that this would be reflected in increasing trends for the ammonia and elements (methane, nitrous oxide) of greenhouse gas indicators.

Ease of interpretation: To clearly communicate to policy makers and the public, with least ambiguity, the state and trends of environmental conditions in agriculture. This involves the need to:

1. ***Limit*** the number and complexity of AEIs given the large differences between the extent of data needs required by researchers compared to those of policy makers and the public who seek a more condensed set of indicators. Efforts to develop "Headline" environmental indicators by some countries are a step in this direction, in an attempt to provide a set of indicators that can become as familiar as economic and social indicators such as inflation and employment rates.
2. ***Reconcile*** the need for indicators that address specific agri-environmental issues within a country or group of countries; provide comparative information across countries; and that are amenable for use in policy modelling.

In order to better serve the needs of policy makers and the public further to narrow the knowledge gaps identified in this section a relatively low-cost option would be to strengthen indicator networks at a number of levels including between:

1. International organisations (*e.g.* OECD, FAO, Eurostat, EEA).
2. Scientists, developers of indicators, policy analysts, farmers, and the agri-food chain.
3. OECD and non-OECD countries; and between.
4. Governments and non-governmental organisations (*e.g.* BirdLife International).

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Environmental Performance of Agriculture in OECD Countries Since 1990

Agriculture can have significant impacts on the environment as it uses on average over 40% of water and land resources in OECD countries. The impacts occur on and off farm, including both pollution and degradation of soil, water and air. But agriculture also supplies ecosystem services, such as biodiversity, provides a sink for greenhouse gases, and contributes to flood control and the aesthetic value of landscapes.

Most OECD countries are tracking the environmental performance of agriculture, which is informing policy makers and society on the state and trends in agri-environmental conditions, and can provide a valuable aid to policy analysis. As countries are increasingly using a wide range of policy measures to address agri-environmental issues, indicators provide crucial information to monitor and analyse the effects of those policies on the environment. They can also help the understanding and analysis of the environmental effects of future policy scenarios and agricultural projections.

This work is unique in many ways. The co-operative process in preparing the indicators ensured that as far as possible they are the most up to date and readily available comparative data on the environmental performance of agriculture in OECD countries. The report includes both those indicators that most closely satisfy the criteria of policy relevance, analytical soundness, measurability and ease of interpretation – in other words those that are most comparable across time and countries – and those that are less developed or of importance to only a few countries or group of countries. This publication also provides valuable agri-environmental information for each OECD country.

www.oecd.org/tad/env/indicators

Further reading:

Environmental Indicators for Agriculture: Vol. 1: Concepts and Framework, Vol. 2: Issues and Design

Environmental Indicators for Agriculture: Methods and Results, Volume 3

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