Organisation for Economic Co-operation and Development
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ENVIRONMENTAL PERFORMANCE OF AGRICULTURE IN OECD COUNTRIES SINCE 1990:

Denmark Country Section

This country section is an extract from chapter 3 of the OECD publication (2008) ***Environmental Performance of Agriculture in OECD countries since 1990***, which is available at the OECD website indicated below.

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A summary version of this report is published as ***Environmental Performance of Agriculture: At a Glance***, see the OECD website which also contains the agri-environmental indicator time series database at: http://www.oecd.org/tad/env/indicators

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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The review of environmental performance draws on the country responses to the OECD agri-environmental questionnaires (unpublished) provided by countries and the OECD agri-environmental database supporting Chapter 1 (see website above).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:

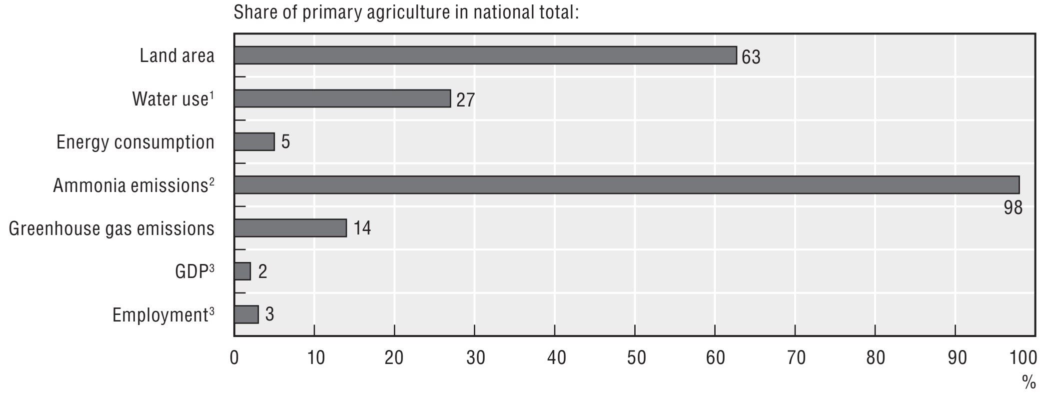
Coverage: The analysis is confined to examination of agri-environmental trends. The influence on these trends of policy and market developments, as well as structural changes in the industry, are outside the scope of these sections. Moreover, the country sections do not examine the impacts of changes 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).

3.6. 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.

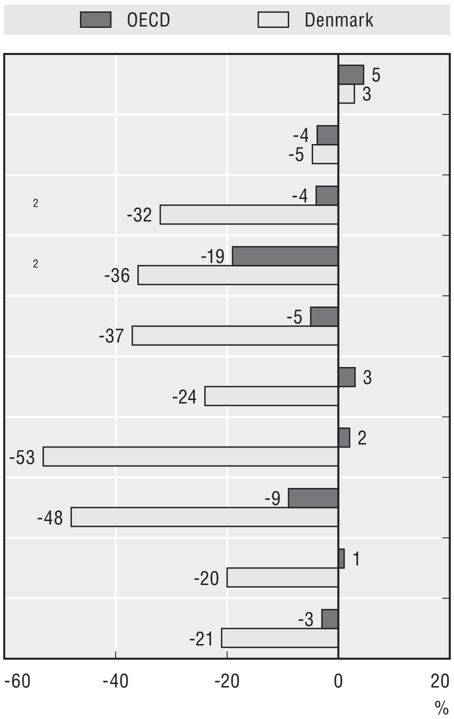
The process of reducing agricultural nutrient pollution of the environment has been difficult and slow, highlighted by the failure of agriculture to meet the government targets under the APAEs, although some success was apparent under APAE II (as noted above) [4]. While the third APAE has set ambitious 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

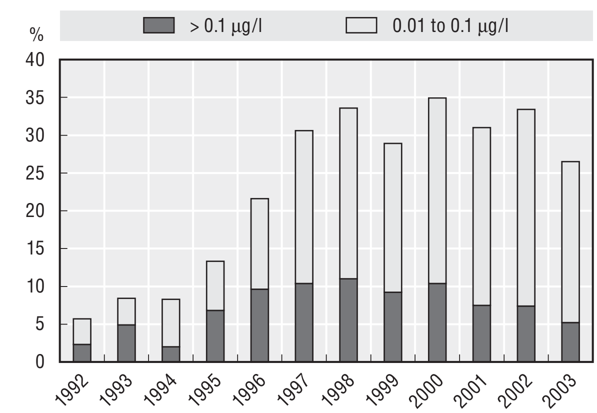
Variable	Unit		Denmark	**OECD**
Agricultural production volume	Index (1999-01 = 100)	1990-92 to 2002-04	103	105
Agricultural land area	000 hectares	1990-92 to 2002-04	–132	–48 901
Agricultural nitrogen (N) balance	Kg N/hectare	2002-04	127	74
Agricultural phosphorus (P) balance	Kg P/hectare	2002-04	11	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.

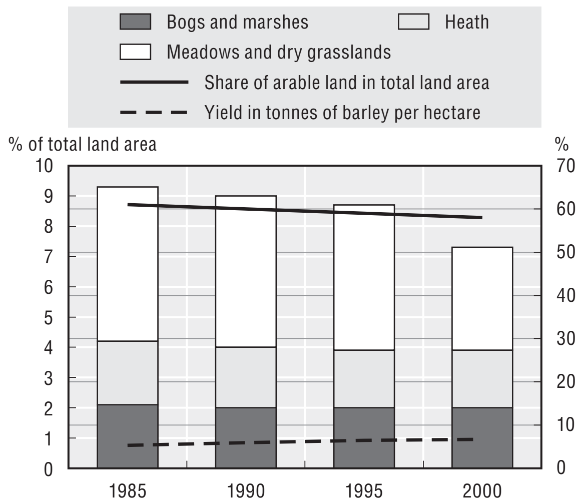
Source: OECD Secretariat. For full details of these indicators, see Chapter 1 of the *Main Report*.

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.

StatLink http://dx.doi.org/10.1787/300070388585

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