Organisation for Economic Co-operation and Development
Organisation de Coopération et de Développement Économiques

ENVIRONMENTAL PERFORMANCE OF AGRICULTURE IN OECD COUNTRIES SINCE 1990:

Chapter 1 Section 1.6
Water

This document is an extract from Chapter 1 of the OECD publication (2008) ***Environmental Performance of Agriculture in OECD countries since 1990***, which is available on the OECD website which also contains the agri-environmental indicator time series database at: www.oecd.org/tad/env/indicators

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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.

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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

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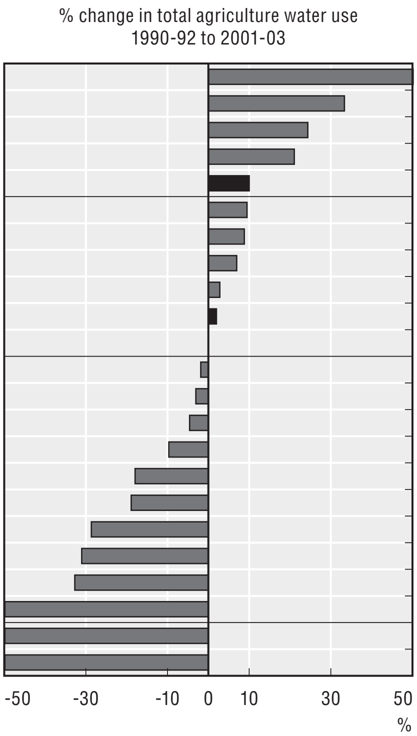
Figure 1.6.1. **Agricultural water use**[1]



	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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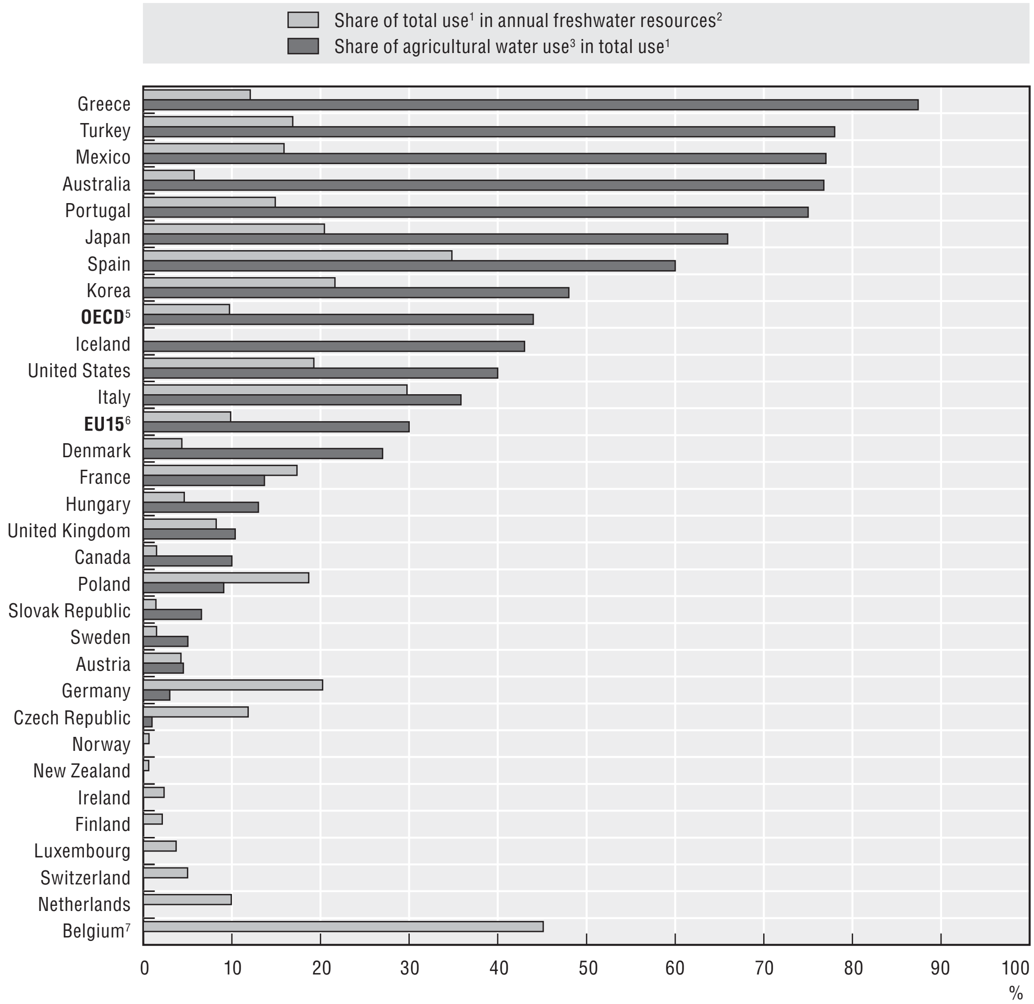
1. Agricultural water use is defined as water for irrigation and other agricultural uses such as for livestock operations. It includes water abstracted from surface and groundwater, and return flows from irrigation but excludes precipitation directly onto agricultural land.
2. Total water use is the 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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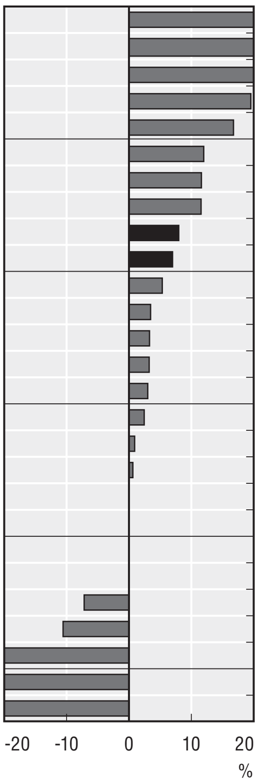
1. Total use (abstractions) of water by all users, including public water supply, agriculture, industry, and for power station cooling.
2. Annual freshwater resources include: Mean annual precipitation + transborder water flows – mean annual evapotranspiration (over-exploitation of groundwater resources 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**

% change in irrigated area 1990-92 to 2001-03



	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

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. .: 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).

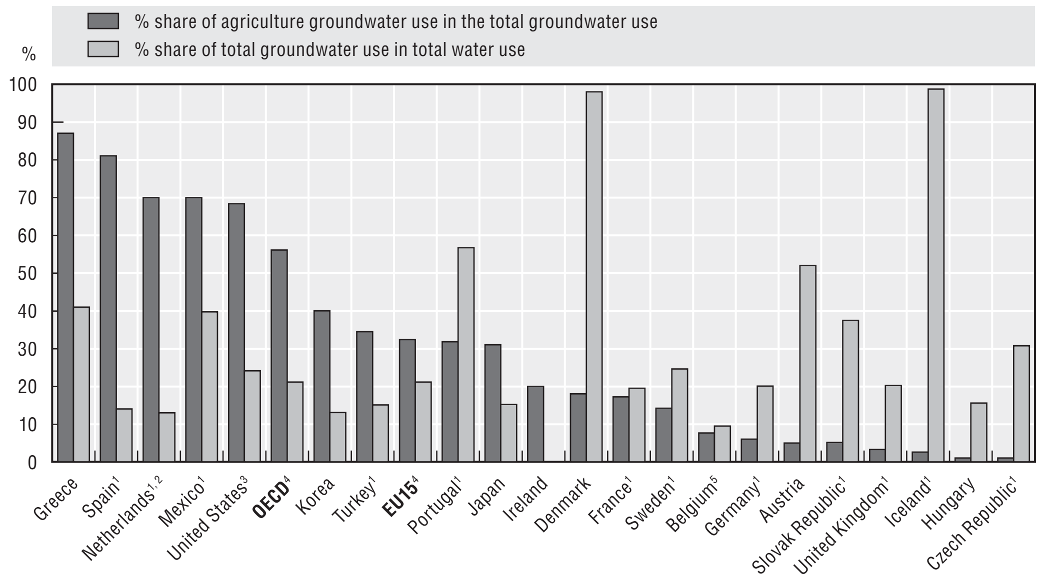
Trends and projections in agricultural water use are of particular concern for groundwater resources. Agriculture's share in total groundwater utilisation is above 30% in a third of OECD countries (Figure 1.6.4). While there is little cross country OECD data on trends in agricultural groundwater use, 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



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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 unvailable.
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).

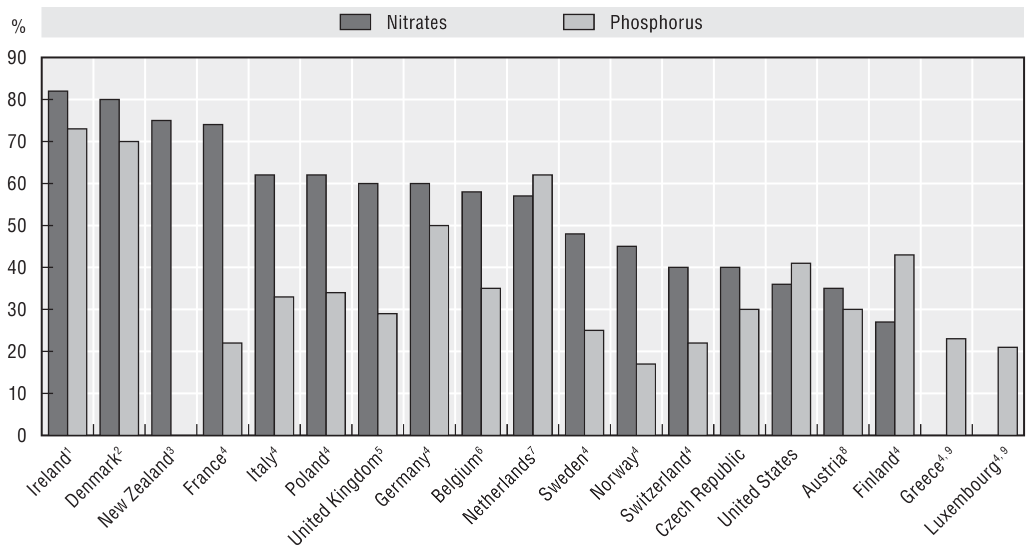
The economic cost of agricultural water pollution is high in many cases. Treating water to remove nutrients and pesticides to ensure water supplies meet drinking standards is significant in some OECD countries. In the **United Kingdom**, for example, the overall economic cost of water pollution from 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



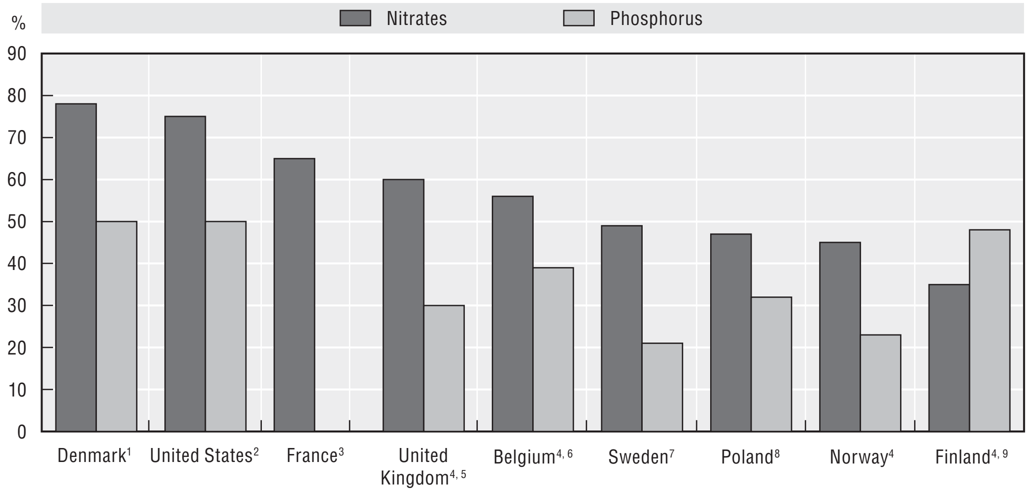
StatLink http://dx.doi.org/10.1787/287220150527

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.

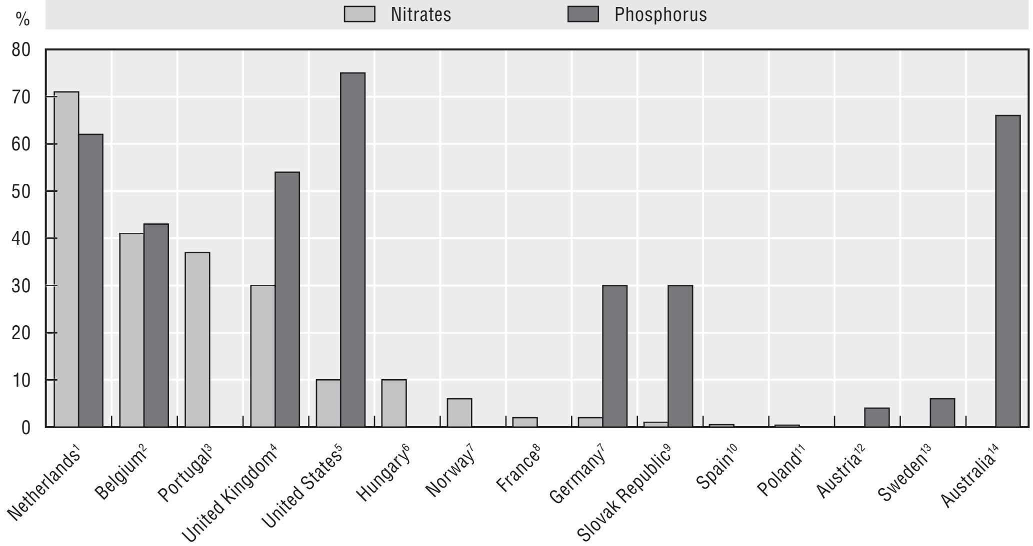
(Figure 1.6.6). But the share of agricultural nitrates in surface and coastal waters can reveal significant fluctuations depending on annual river flows, such as in the **United Kingdom** (Chapter 3).

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.

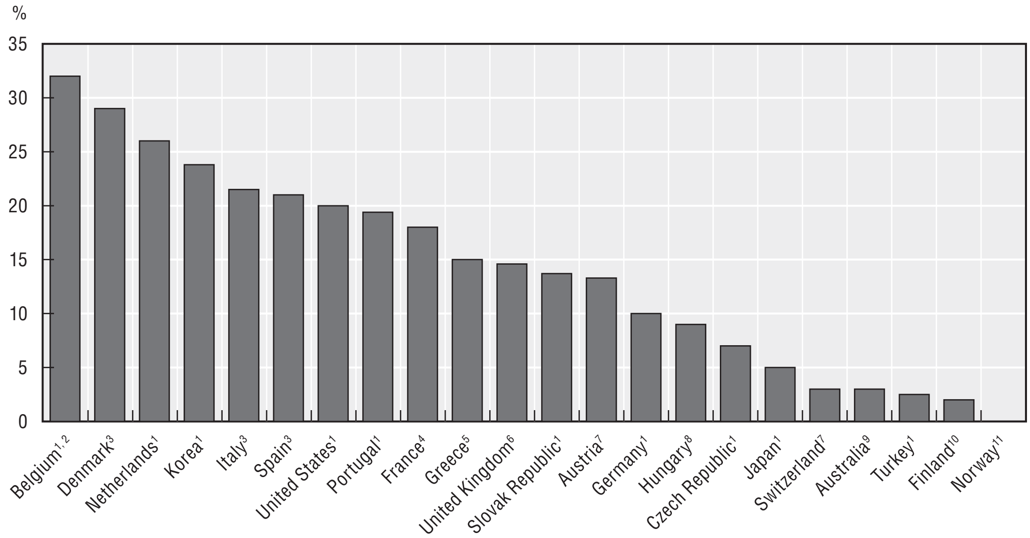
Source: OECD Agri-environmental Indicators Questionnaire, unpublished; OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France.

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.

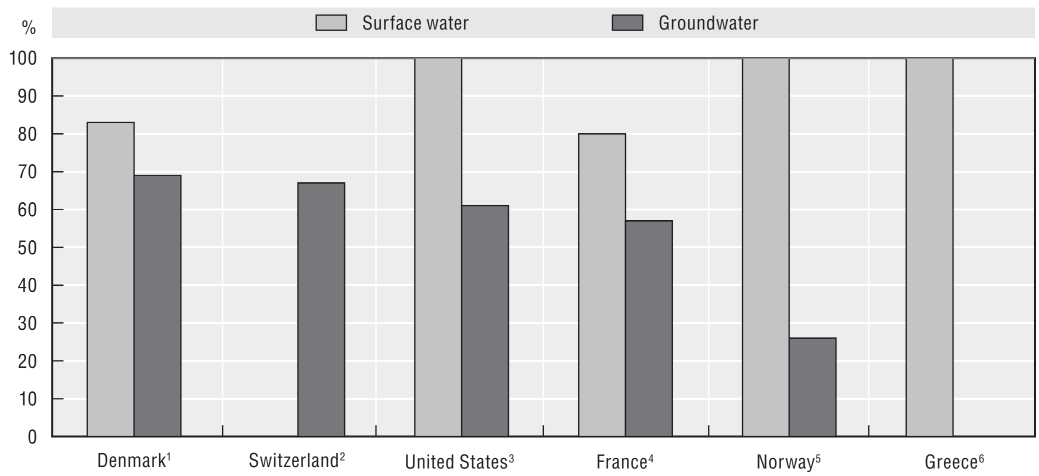
Pesticides

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



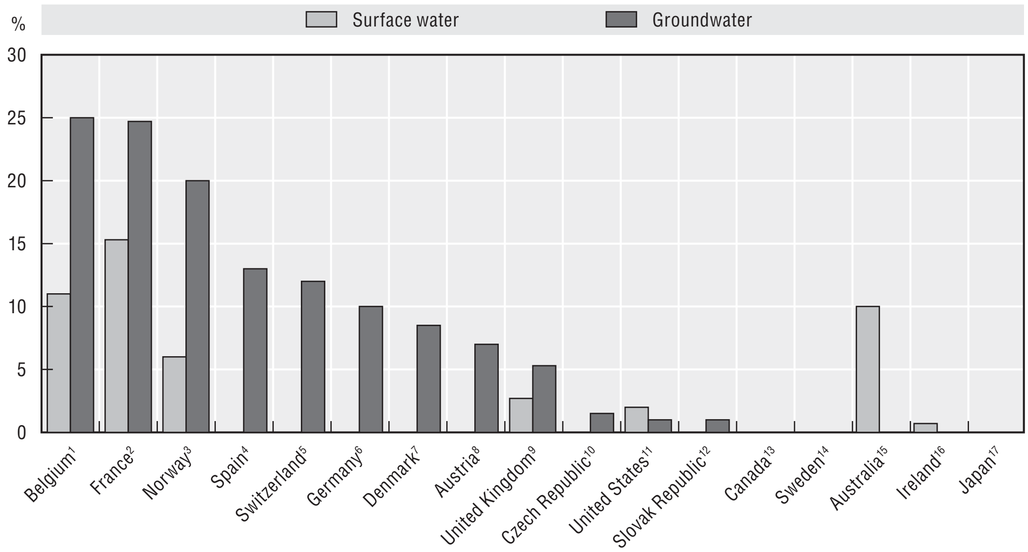
StatLink http://dx.doi.org/10.1787/287348331384

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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