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Environmental Performance of Agriculture in OECD Countries
since 1990

Chapter 1

OECD Trends of Environmental Conditions related to Agriculture since 1990

1.1. AGRICULTURAL PRODUCTION AND LAND

KEY TRENDS

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

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

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

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

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

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

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

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1.1.1. Introduction

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

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

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

1.1.2. Agricultural production

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

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

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

2002-04 (million tonnes)

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

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

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

Source: FAOSTAT (2006).

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

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

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

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

Source: FAOSTAT (2006).

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

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

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

1.1.3. Agricultural land use

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

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

Annual percentage growth rates

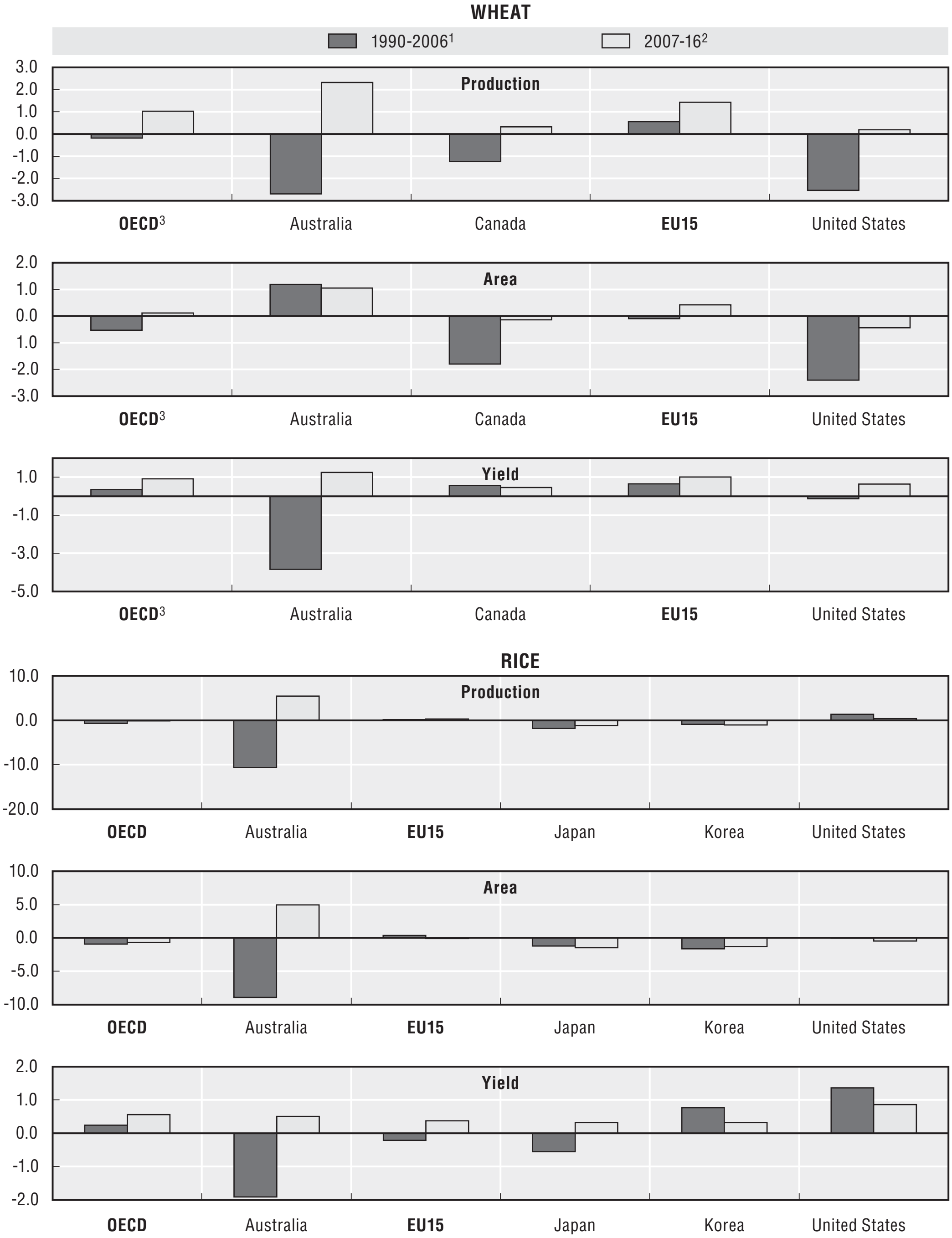
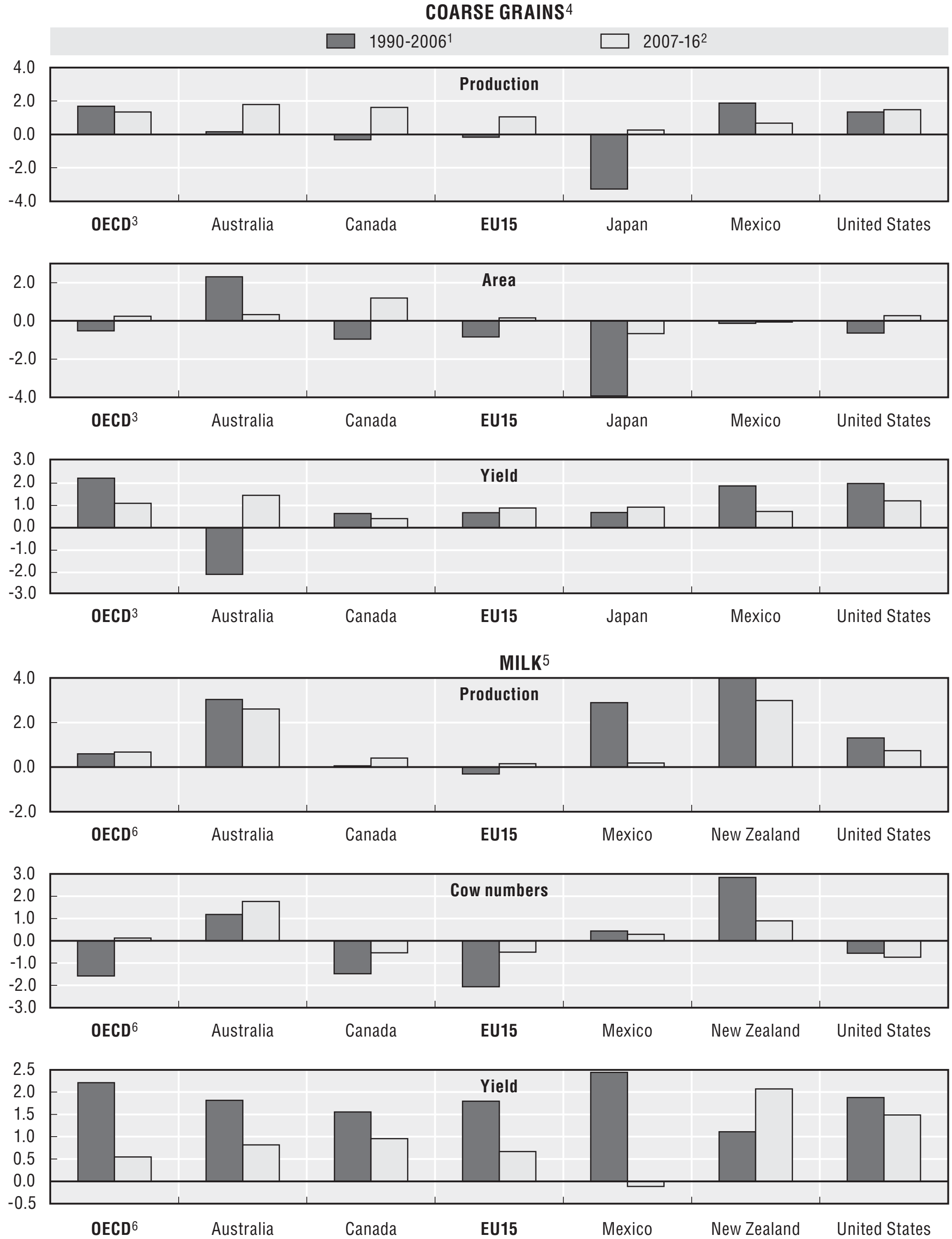


Figure 1.1.1. **Production, yields and area harvested and future projections for selected commodities and OECD countries** *(cont.)*

Annual percentage growth rates



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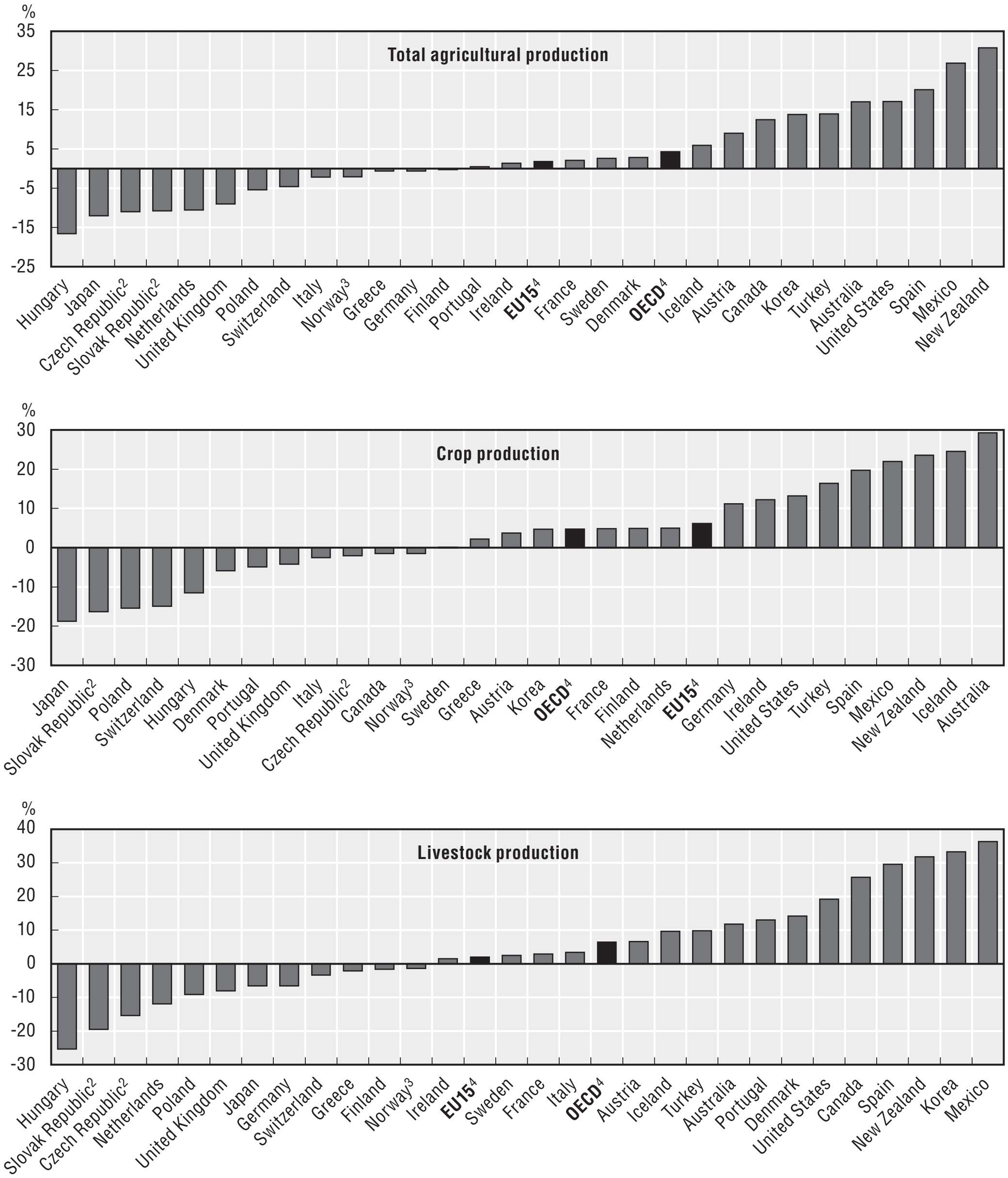
1. 1990-2006, actual trends, 2006 estimate.
2. 2007-16, projections using the OECD Aglink model, OECD (2007).
3. OECD and country average 1990-2006 = average 1995-2006.
4. Coarse grains include: barley, rye, oats, millets, sorghum, buckwheat, quinoa, fonio, triticale, canary seed, mixed grain and cereals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

Source: OECD (2007).

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

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



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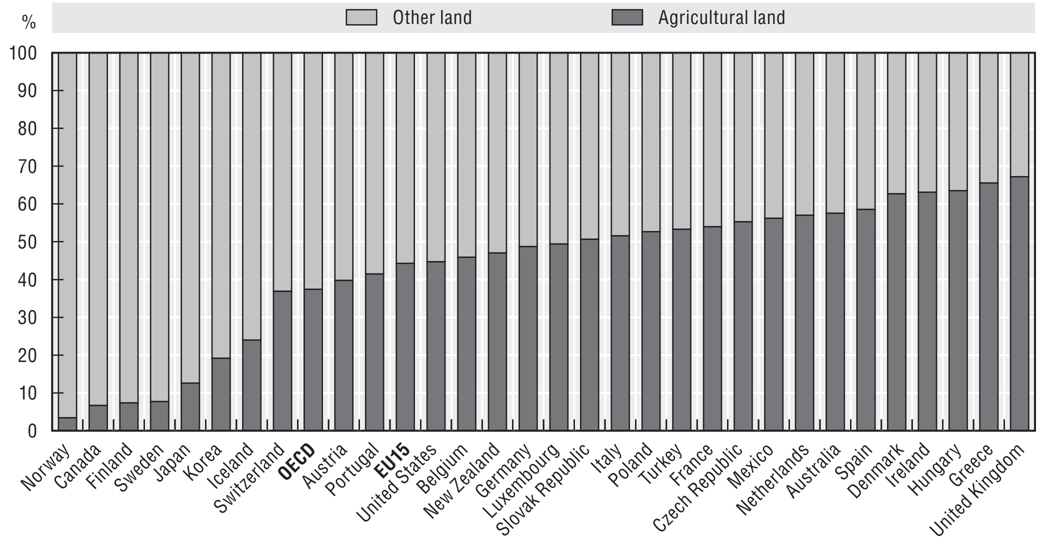
1. The FAO indices of agricultural production show the relative level of the aggregate volume of agricultural production for each year in comparison with the base period 1999-2001. They are based on the sum of price-weighted quantities of different agricultural commodities produced after deductions of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

Source: FAOSTAT (2006).

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

Average 2002-04



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

Source: FAOSTAT (2006); and national data.

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

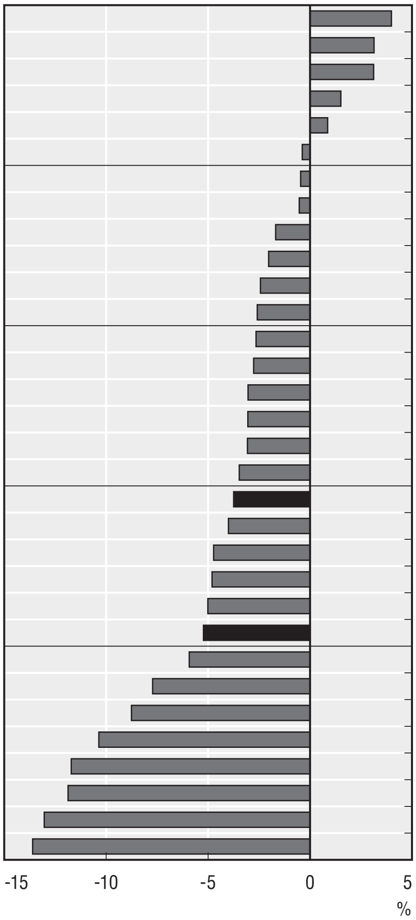
- ***Use***, in commodity production and provision of ecosystem services, such as biodiversity, carbon sequestration, water retention and flood control capacity; and cultural landscape.
- ***Ownership***, in particular, the property right issues related to land and water (OECD, 1997a).
- ***Policies***,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

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

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

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

Figure 1.1.4. **Agricultural land area**



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

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

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

Source: FAOSTAT (2006); and national data.

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

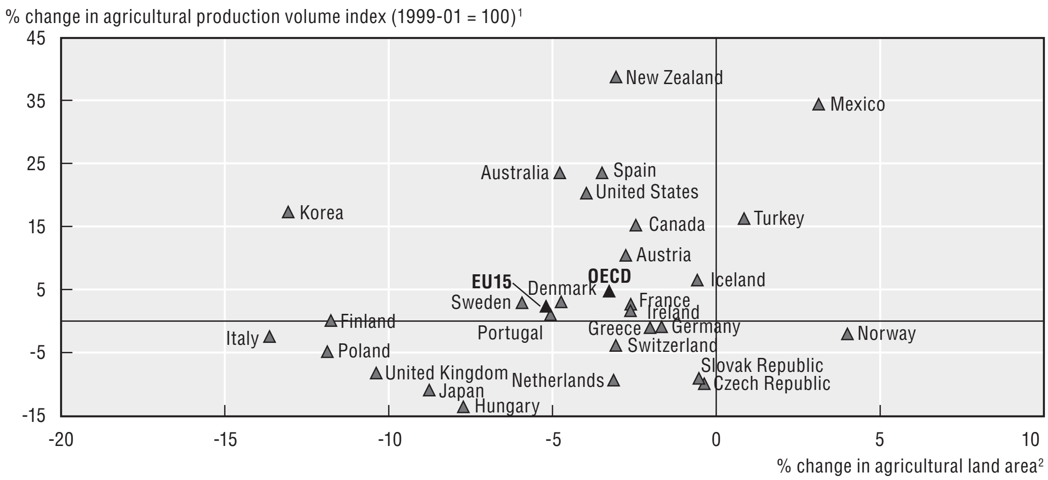
Changes in the overall size and composition of livestock inventories have important implications for discharges of nutrients into soil, water and the air, while changes in stocking densities can have effects on soil erosion and biodiversity. Also the production systems to rear livestock can have varying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

1.1.4. Linkages between agricultural production and land use

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

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

1990-92 to 2002-04



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

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

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

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

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

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

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

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

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1.2. NUTRIENTS

KEY TRENDS

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

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

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

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

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

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

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

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Indicator definitions:

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

Concepts and interpretation

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

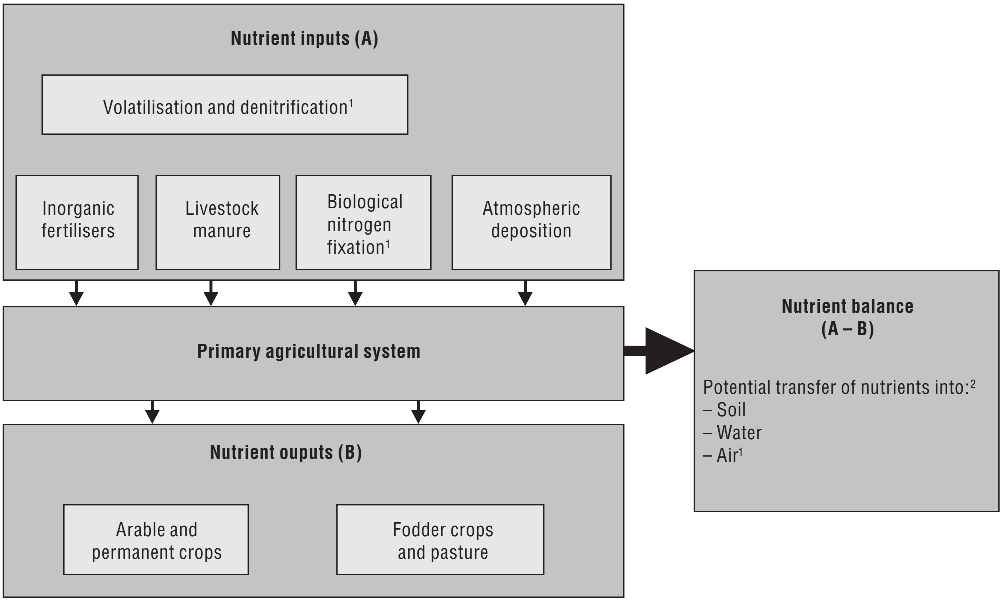
There are a complex range of physical processes that affect nutrient supplies in an agricultural system, illustrated by nutrient cycles (OECD, 2005a; 2005b). The extent to which these processes can harm the environment will depend on the: type of nutrients applied to crops; efficiency of crop nutrient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

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

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

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

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



StatLink http://dx.doi.org/10.1787/286307437441

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

Source: OECD (2007a; 2007b).

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

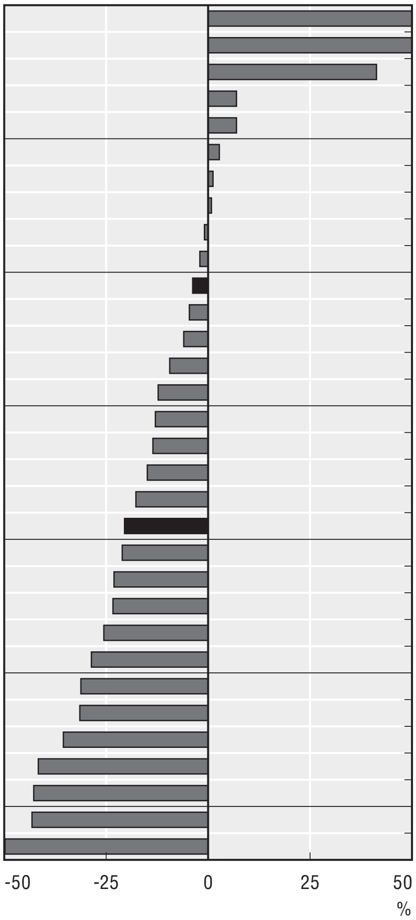
While the nutrient balances are calculated at the national level, the same methodology can be used to estimate regional (sub-national) balances. This is important given the significant spatial variation in balances around national average values. Hence, national values need to be interpreted with caution.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

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

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

Figure 1.2.2. **Gross nitrogen balance estimates**

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



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

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

Source: OECD Secretariat (2007).

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

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

Recent trends

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

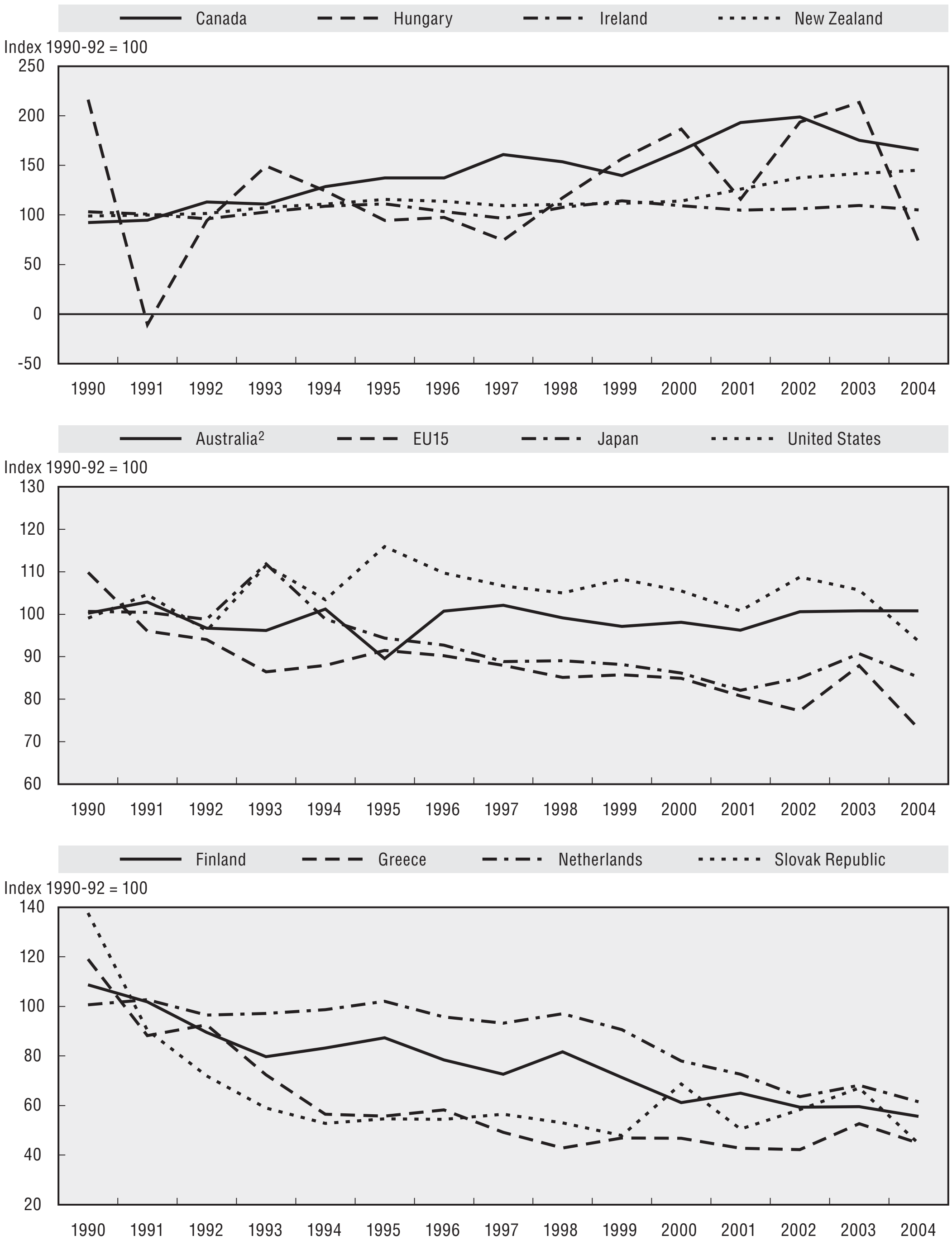
1.2.1. Nitrogen balance

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

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

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

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



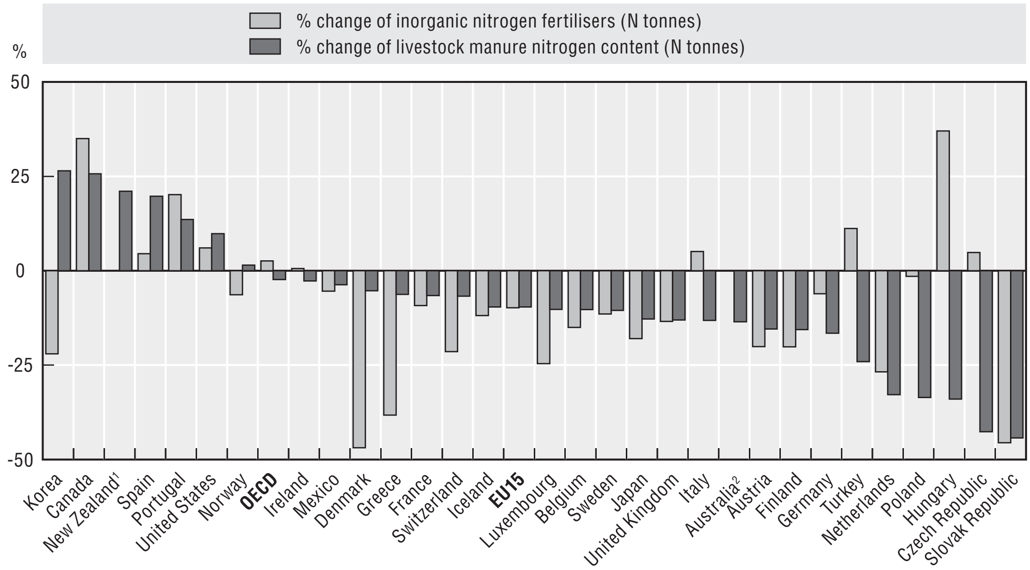
StatLink http://dx.doi.org/10.1787/286360472513

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

Source: OECD Secretariat (2007).

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

1990-92 to 2002-04



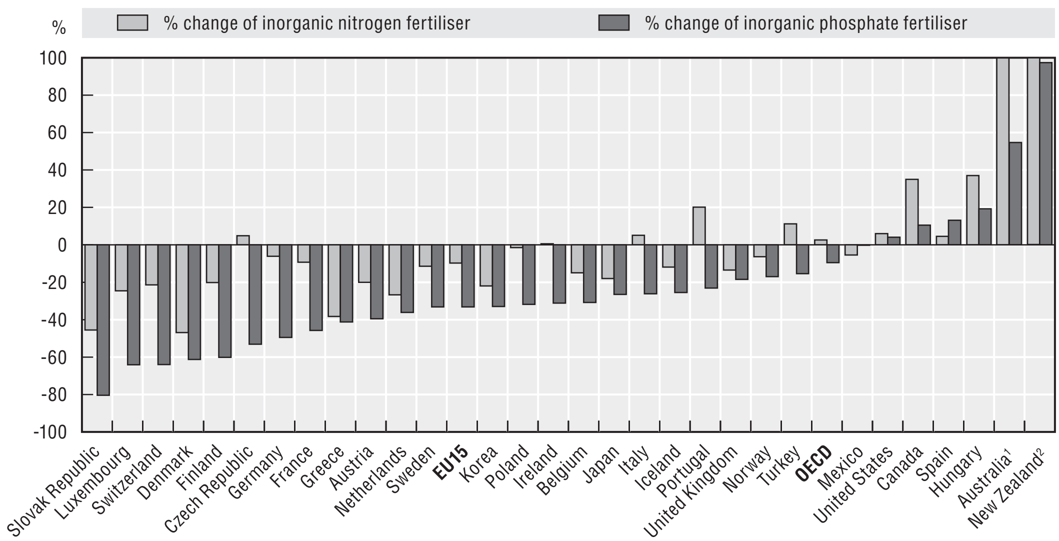
StatLink http://dx.doi.org/10.1787/286364526277

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

Source: OECD Secretariat (2007).

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

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



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

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

Source: OECD Secretariat (2007).

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

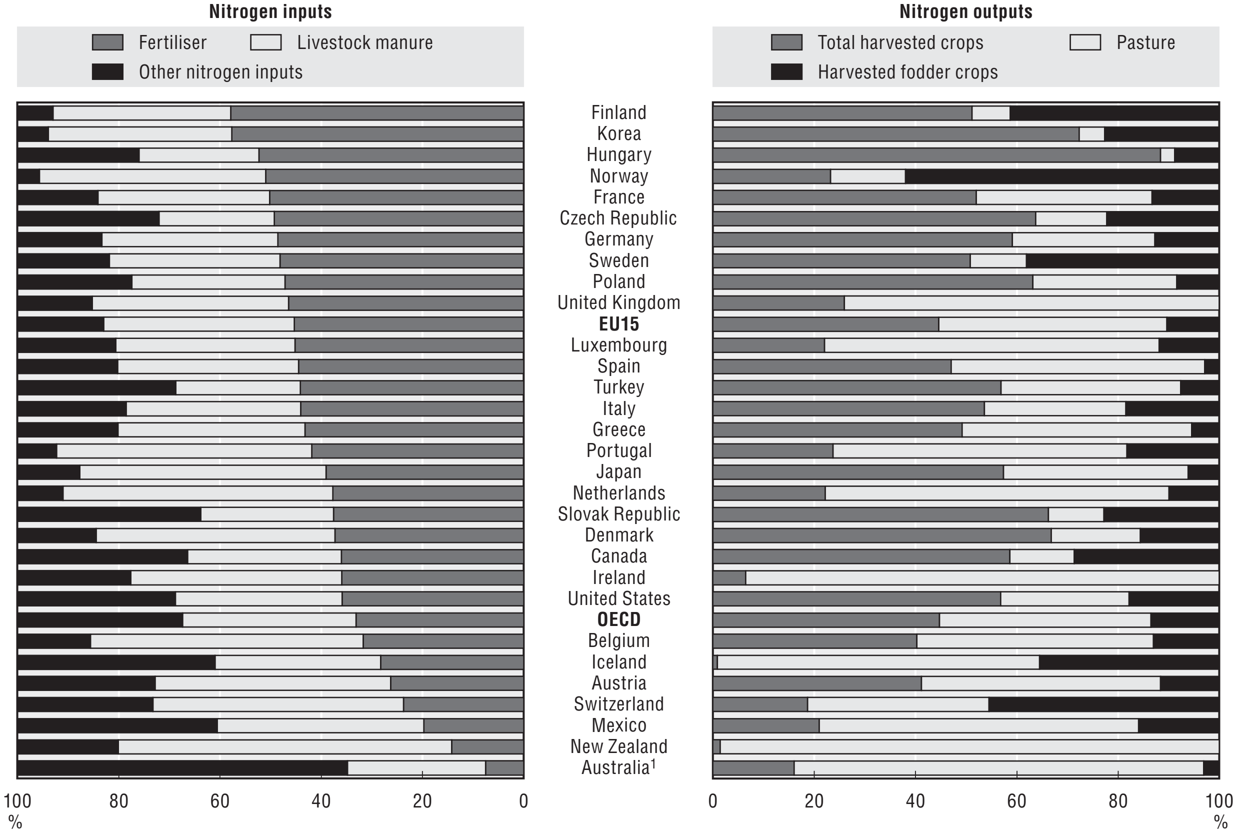
For some countries where N surpluses have risen over the past decade, the uptake of nutrient management plans (NMPs) has been relatively low (**Ireland, New Zealand, Spain**), but for **Canada, Korea** and the **United States** while the uptake of NMPs has been also been relatively low, adoption rates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

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

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

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

Average 2002-04



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

Source: OECD Secretariat (2007).

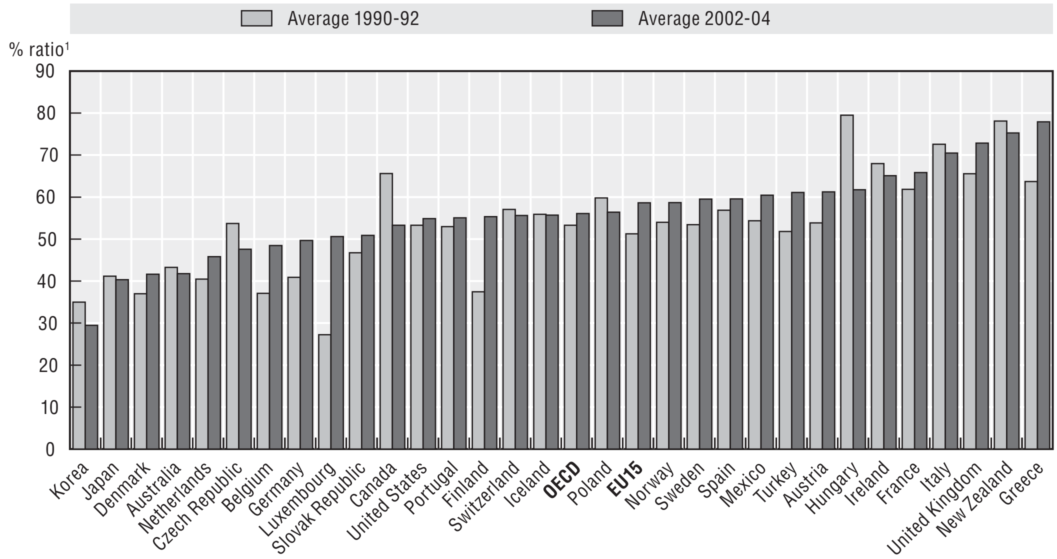
Also for some countries where N use efficiency is low by average OECD levels (**Japan, Korea**) they are also countries with higher than the OECD average intensity of kgN/ha of farmland and poor uptake by farmers of nutrient management plans (Section 1.9).

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

1.2.2. Phosphorus balance

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

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



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

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

Source: OECD Secretariat (2007).

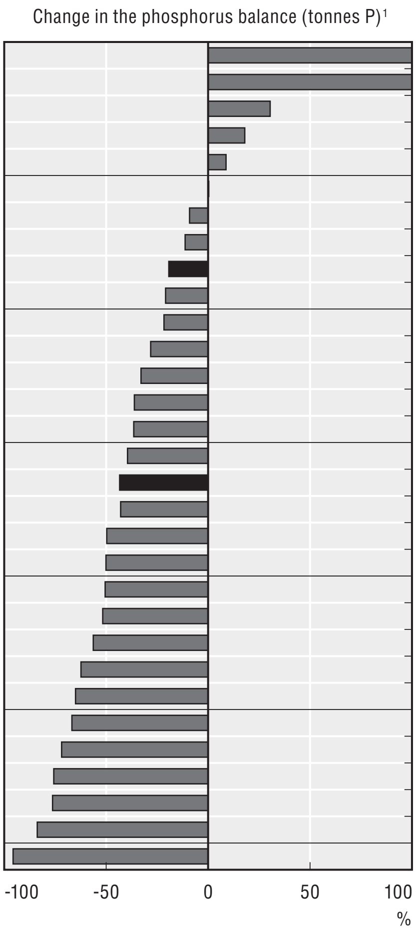
However, the intensity of kgP/ha of agricultural land for some of these countries still remain among the highest across the OECD, notably for the **Netherlands** (Figure 1.2.8). This is in contrast to many of the countries where tonnes of P surpluses have risen although their intensity of kgP/ha of agricultural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

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

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

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

Figure 1.2.8. **Gross phosphorus balance estimates**



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

StatLink http://dx.doi.org/10.1787/286525166013

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

Source: OECD Secretariat (2007).

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

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

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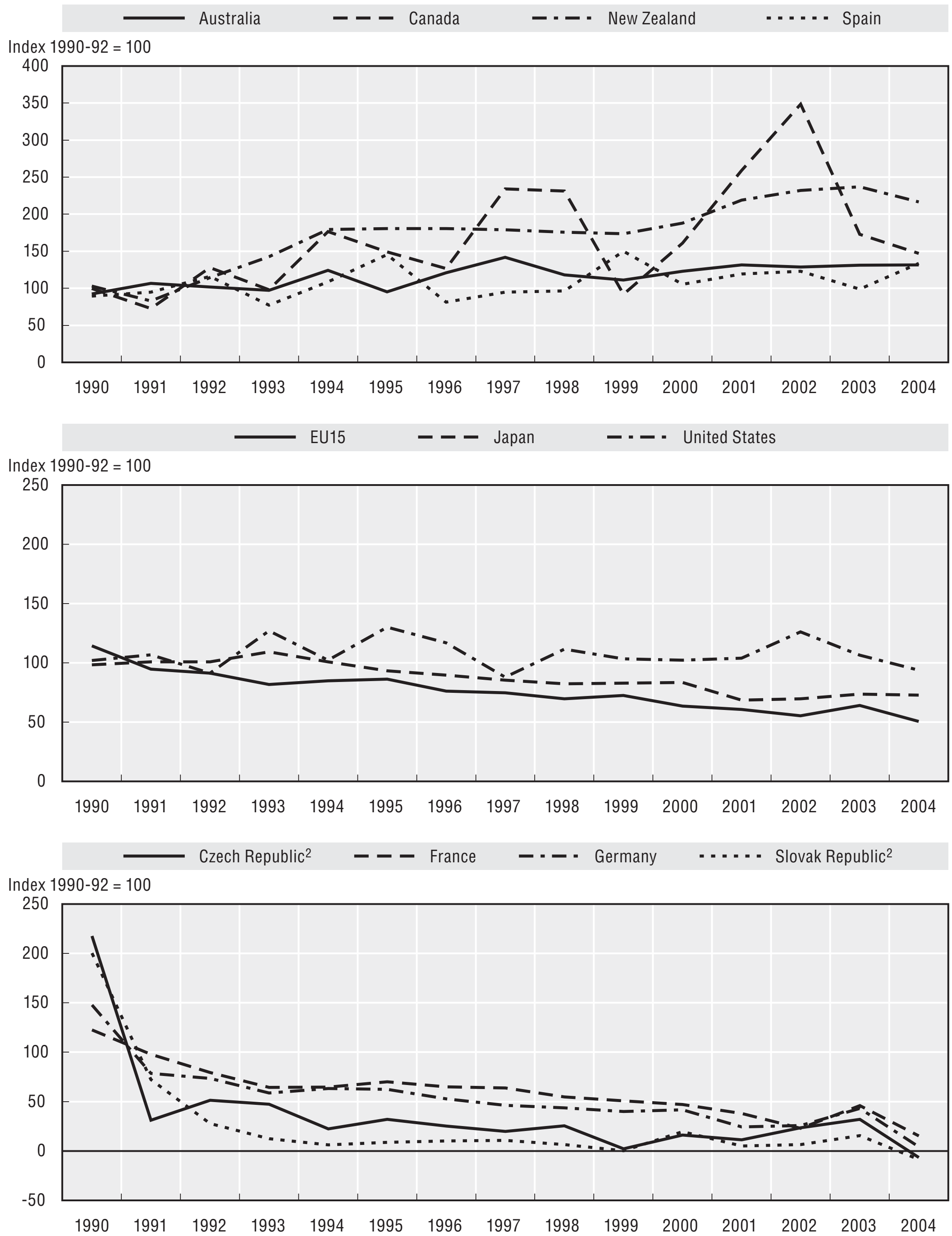
Figure 1.2.9. **Gross phosphorus balance[1] for selected OECD countries**



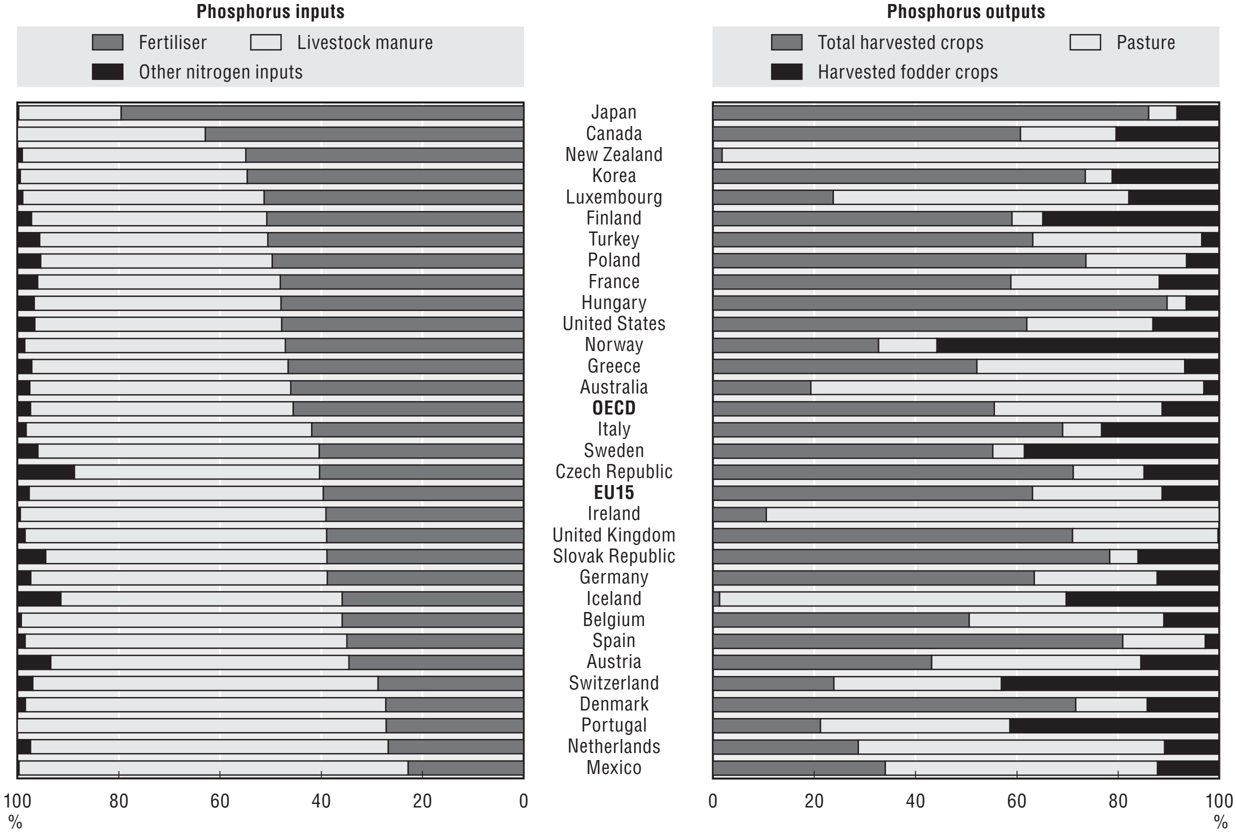
StatLink http://dx.doi.org/10.1787/286545884853

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

Source: OECD Secretariat (2007).

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

Average 2002-04



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

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

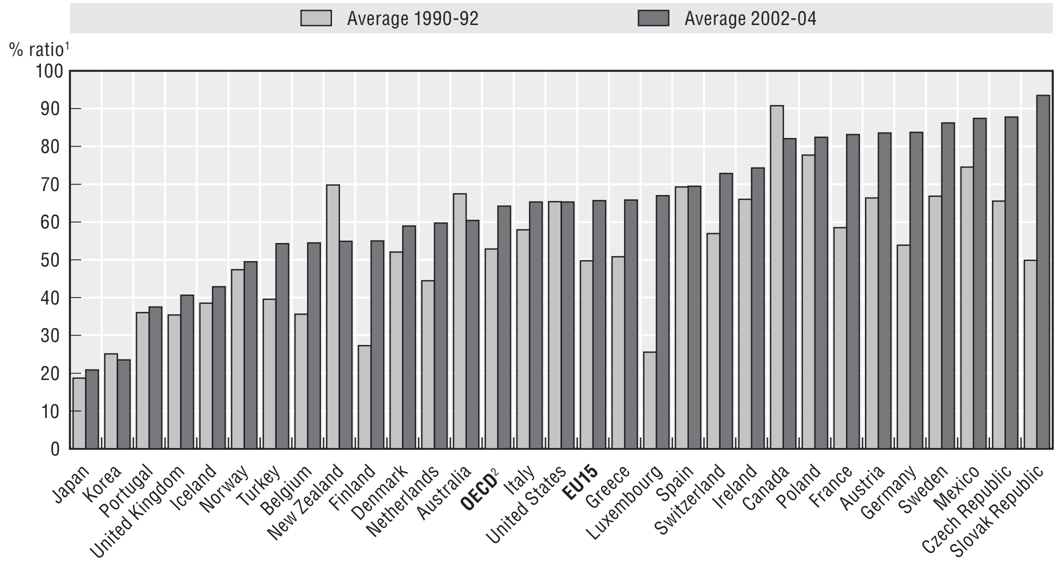
Source: OECD Secretariat (2007).

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

1.2.3. Regional (sub-national) nutrient balances

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

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



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

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

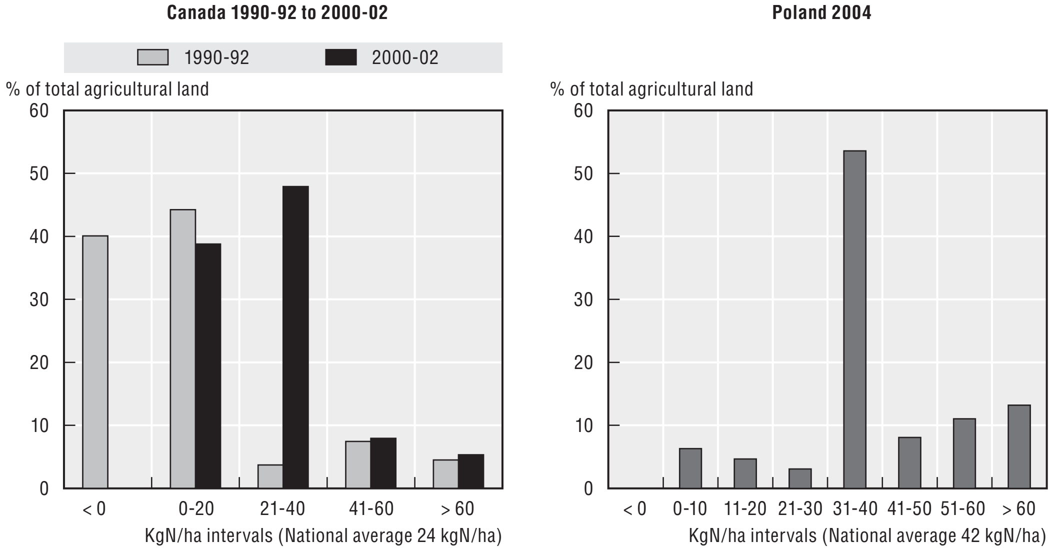
Source: OECD Secretariat (2007).

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

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

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

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



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

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

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1.3. PESTICIDES

KEY TRENDS

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

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

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

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

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

1.3.1. Pesticide use

Indicator definition:

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

Concepts and interpretation

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

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

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

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

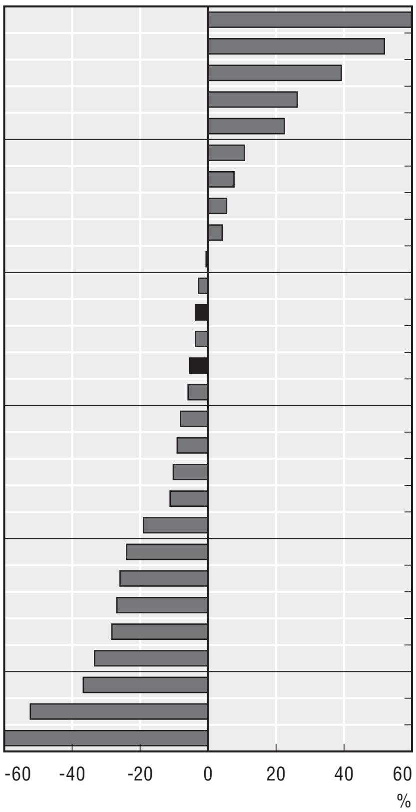
As an environmental ***driving force*** the pesticide use indicator, including the indicator of the use of methyl bromide which has potential to deplete the ozone layer (Section 1.7.2), is linked to pesticide risk indicators (Section 1.3.2) and the ***state*** or presence/concentration of *pesticides in water bodies* (Section 1.6.2). ***Responses*** to these changes in the state of the environment are revealed through indicators of *pest management* and *environmental farm planning*, including organic farming (Section 1.9).

Recent trends

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

Figure 1.3.1. **Pesticide use in agriculture**

Change in tonnes of active ingredients (%)



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

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

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

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

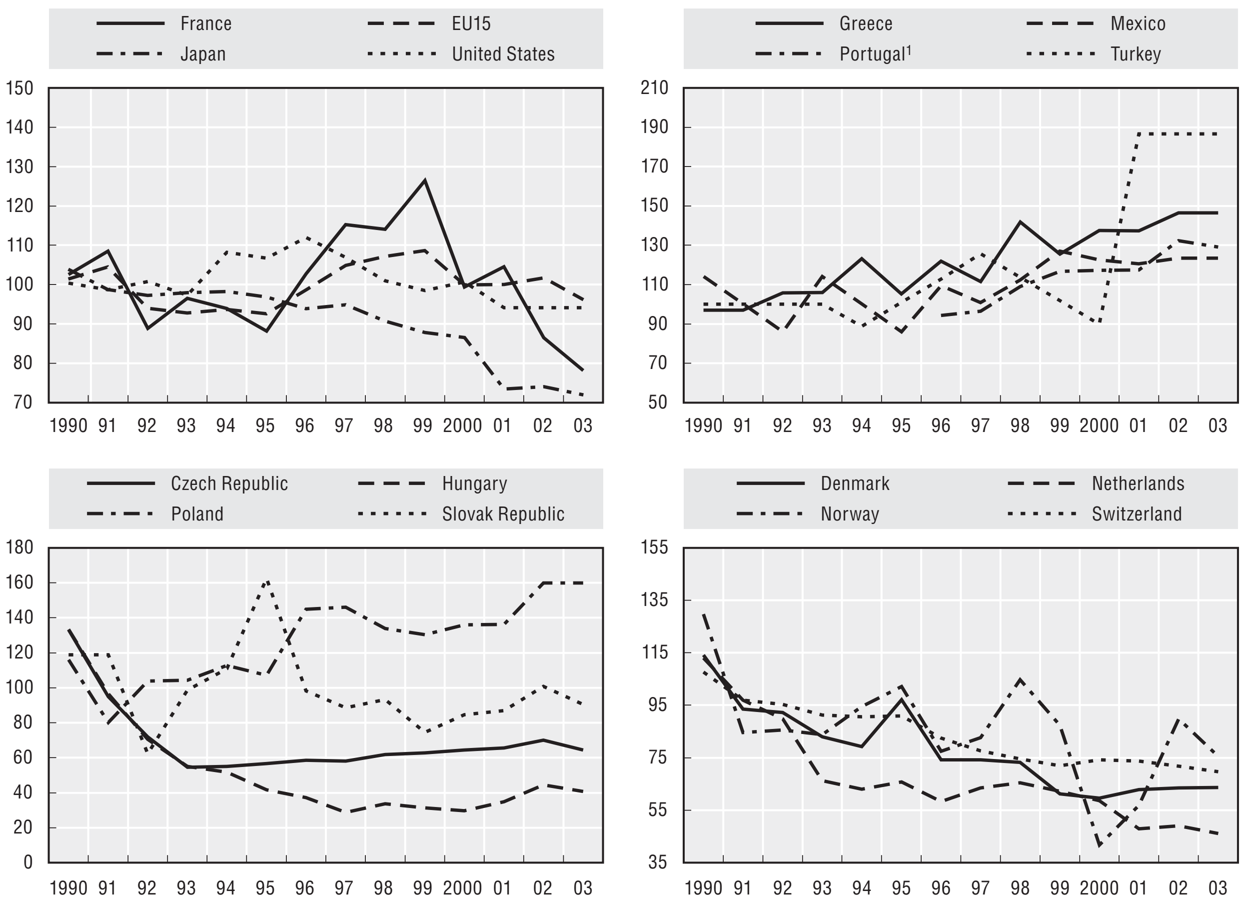
Source: OECD Environmental Data Compendium 2004, Paris, France; OECD Secretariat estimates; and national data sources.

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

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

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

Index 1990-92 = 100



StatLink http://dx.doi.org/10.1787/286706371517

Note: Caution is required in comparing trends across countries because of differences in data definitions, coverage and time periods.

1. Pesticide use index 1996-98 average = 100.

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

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

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

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

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

1.3.2. Pesticide risk indicators

Indicator definition:

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

Concepts and interpretation

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

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

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

The sixth model uses a similar basic formula:

(amount sold/dose)/total arable land treated

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

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

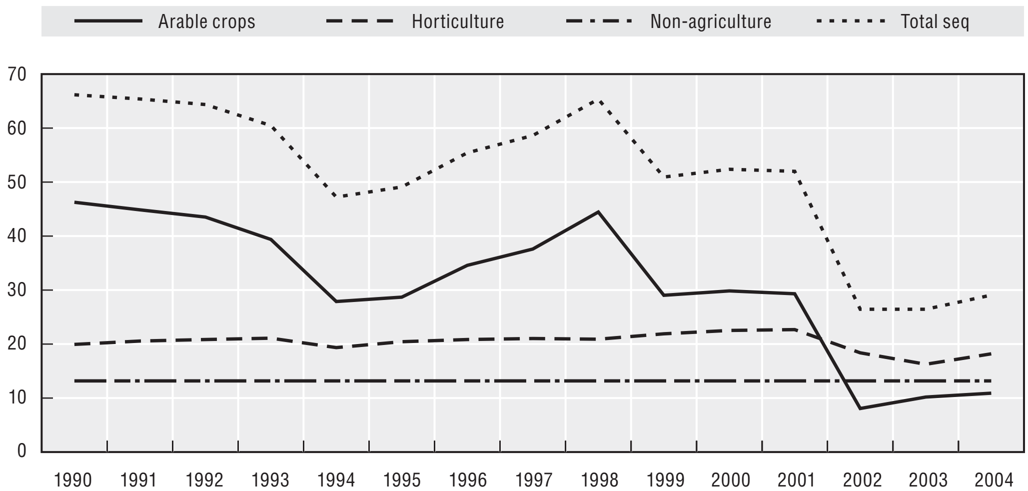
Recent trends

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

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

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

Spreads equivalents in billions

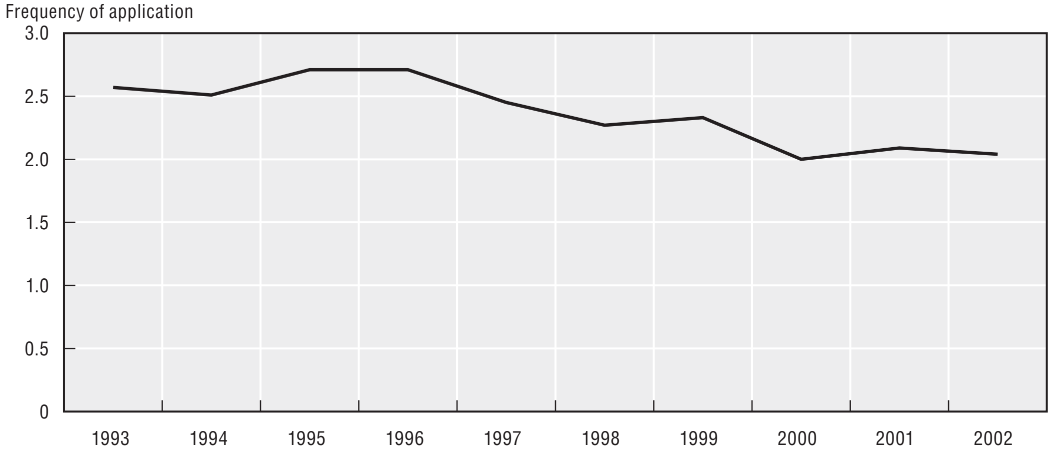


StatLink http://dx.doi.org/10.1787/286707848675

Source: Department of Crop Protection, University of Gent.

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

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



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

Source: Gravesen (2003).

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

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

1987 to 2004 (1987 = 100)

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

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

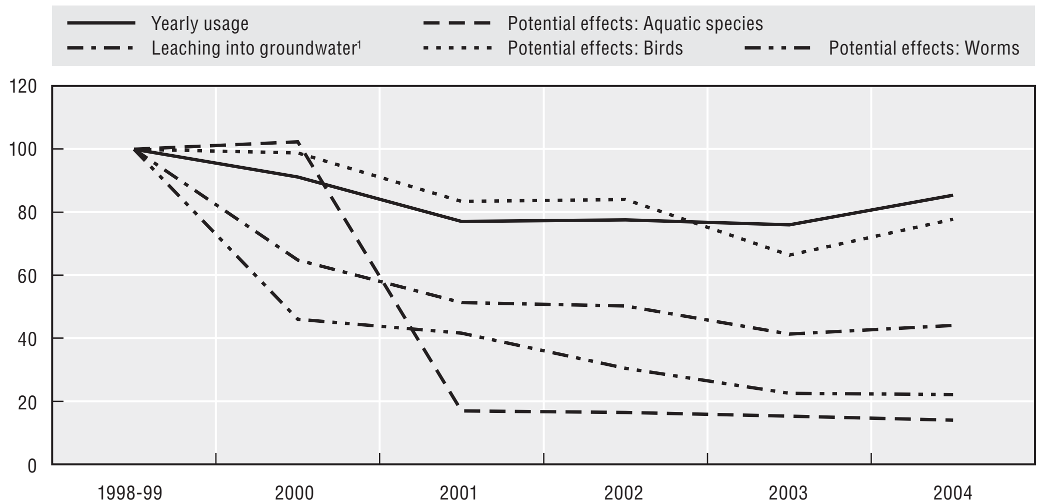
Source: Federal Biological Research Centre for Agriculture and Forestry, Berlin-Braunschweig.

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

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

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

Index 1998-99 = 100



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

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

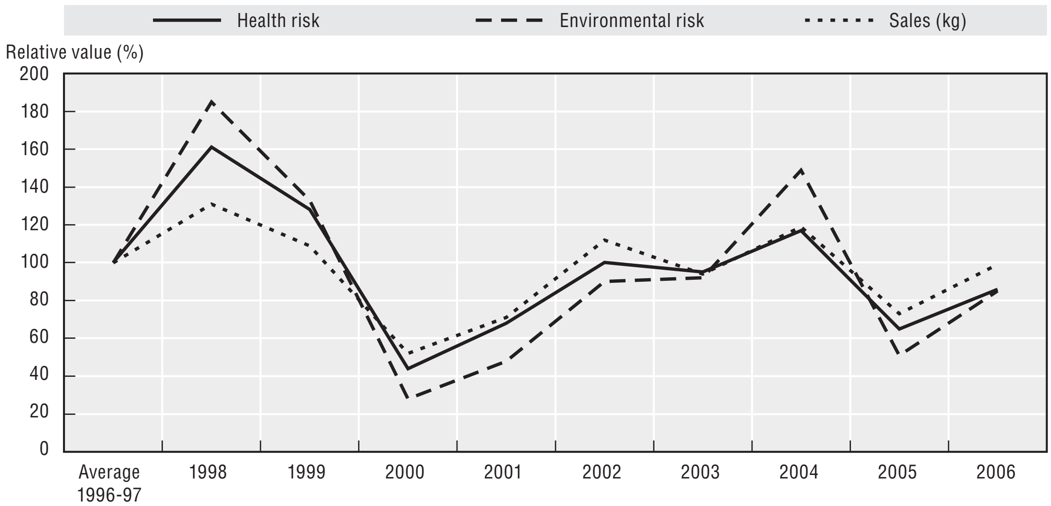
Source: Deneer *et al.* (2003) and RIVM.

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

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

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

Average 1996-97 = 100



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

Source: The Norwegian Food Safety Authority.

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

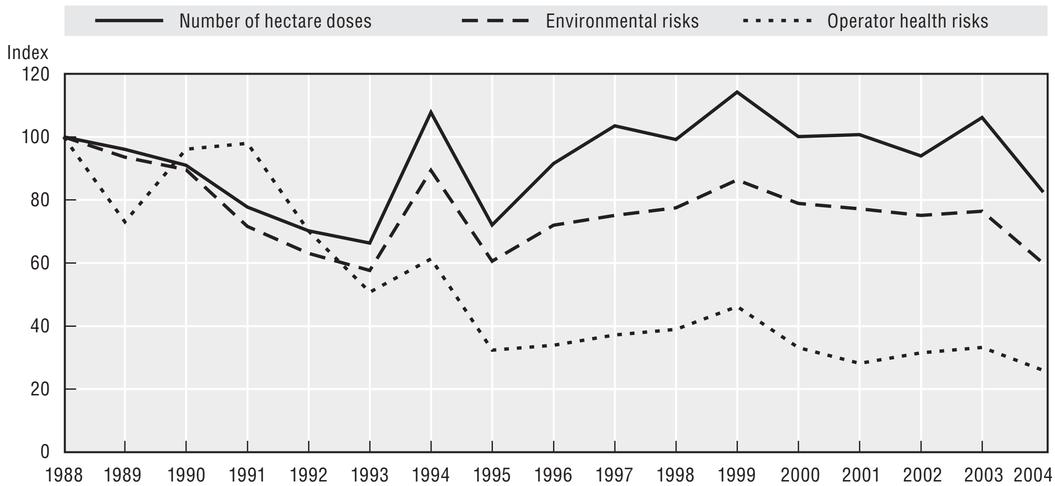
Even though trends are moving in a positive direction, the results from the monitoring programmes on foodstuffs and the environment indicate that the situation is still not entirely satisfactory. Between 2000 and 2006, pesticide sales steadily rose (allowing for some annual fluctuations) and as a consequence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

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

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

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

Index 1988 = 100

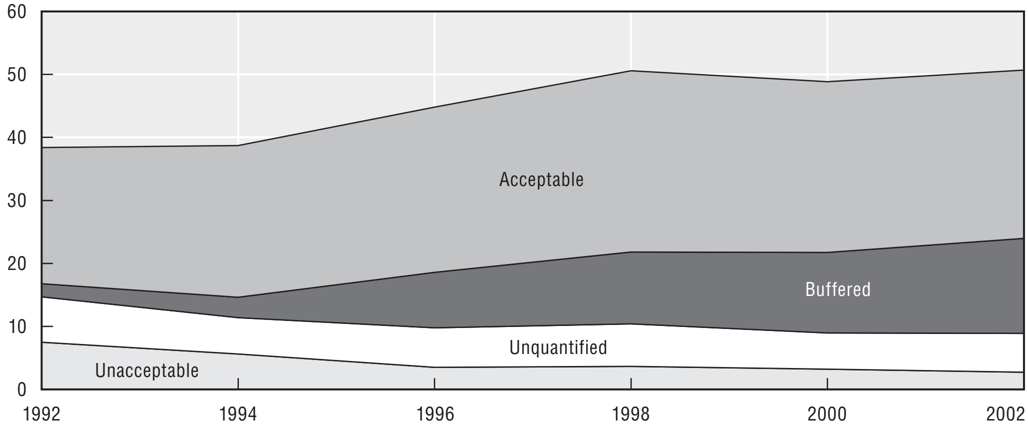


StatLink http://dx.doi.org/10.1787/286827123563

Source: Bergkvist, 2005.

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

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



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

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

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

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

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

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

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

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1.4. ENERGY

KEY TRENDS

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

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

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

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

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

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

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

Indicator definition:

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

Concepts and interpretation

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

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

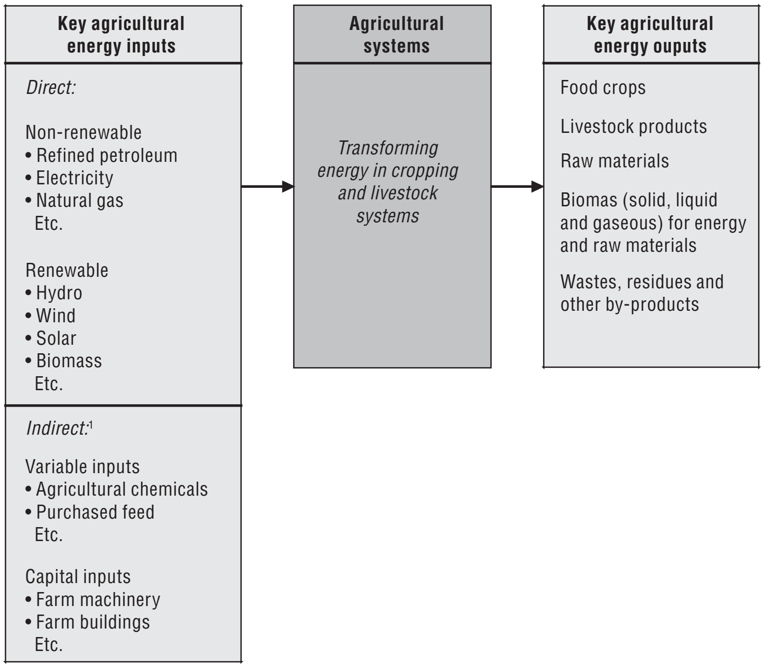
Energy indicators have been in use for some time both at the national and international level (Cleveland, 1995; EEA, 2005; IEA, 2002; OECD, 2002; Wells, 2001; World Bank, 2002). A simple model for energy consumption in agriculture is shown in Figure 1.4.1. *Direct* on-farm energy consumption by primary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

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

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

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

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



StatLink http://dx.doi.org/10.1787/286855521384

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

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

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

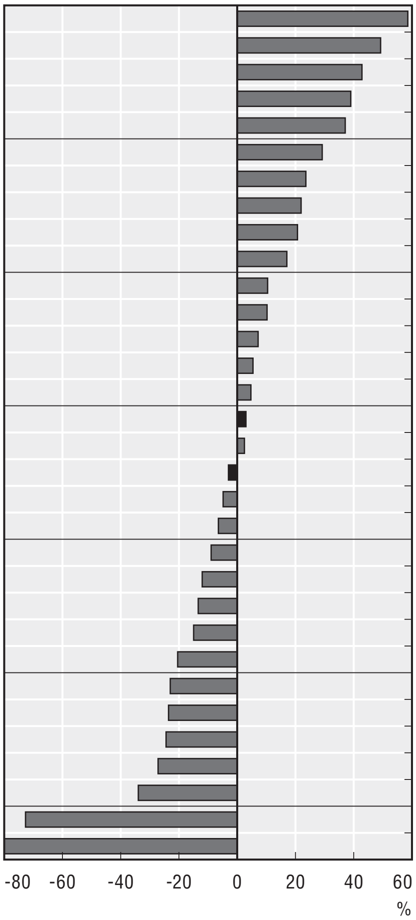
Recent trends

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

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

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

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



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

StatLink http://dx.doi.org/10.1787/286880402436

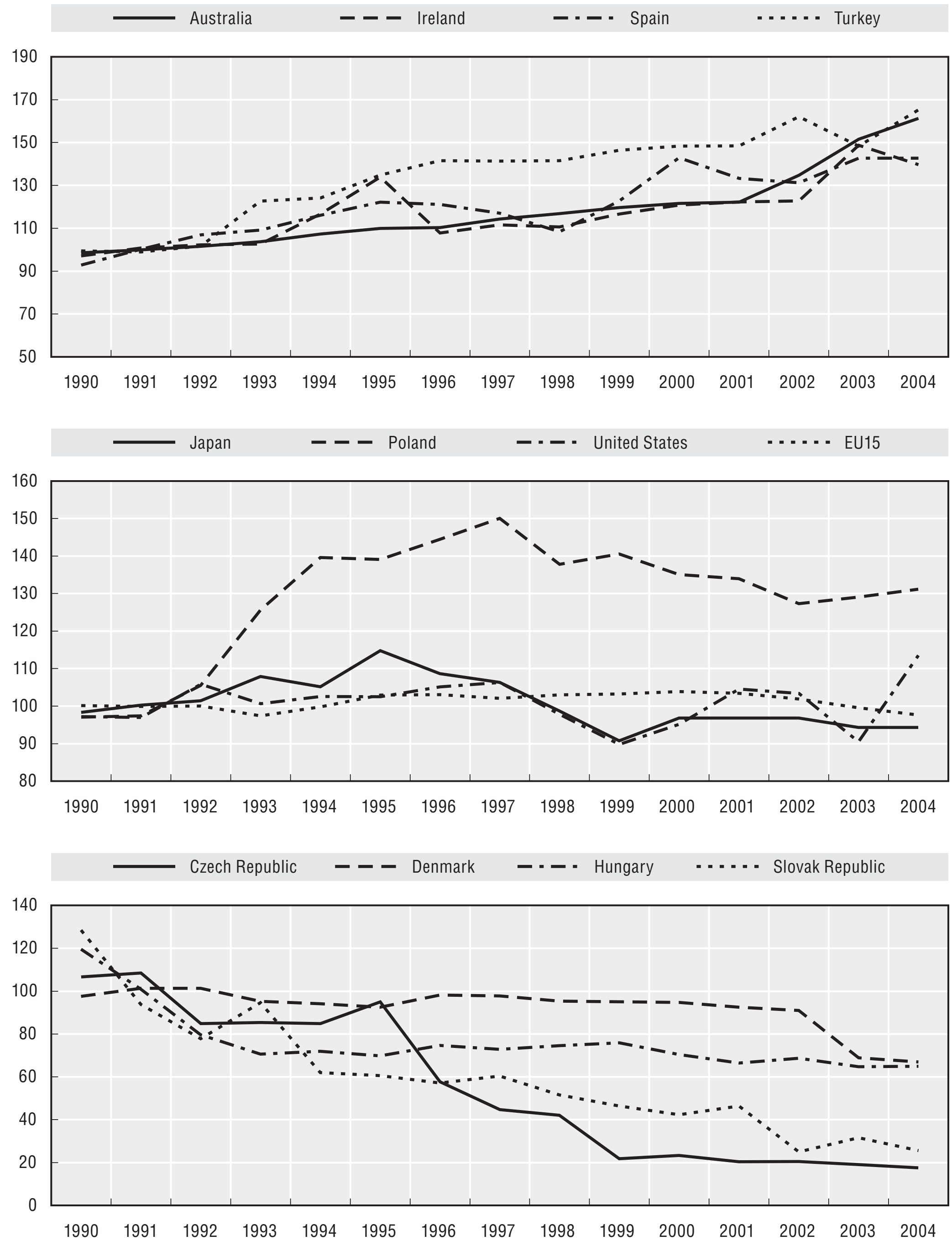
1. Data cover total on-farm energy consumption by primary agriculture (for irrigation, drying, horticulture, machinery and livestock housing), forestry, fishing and hunting, except Belgium, Italy, Switzerland and the United Kingdom, where data only include agriculture.
2. Ktoe equals thousand tonnes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

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

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

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

1990-92 = 100



StatLink http://dx.doi.org/10.1787/287001341115

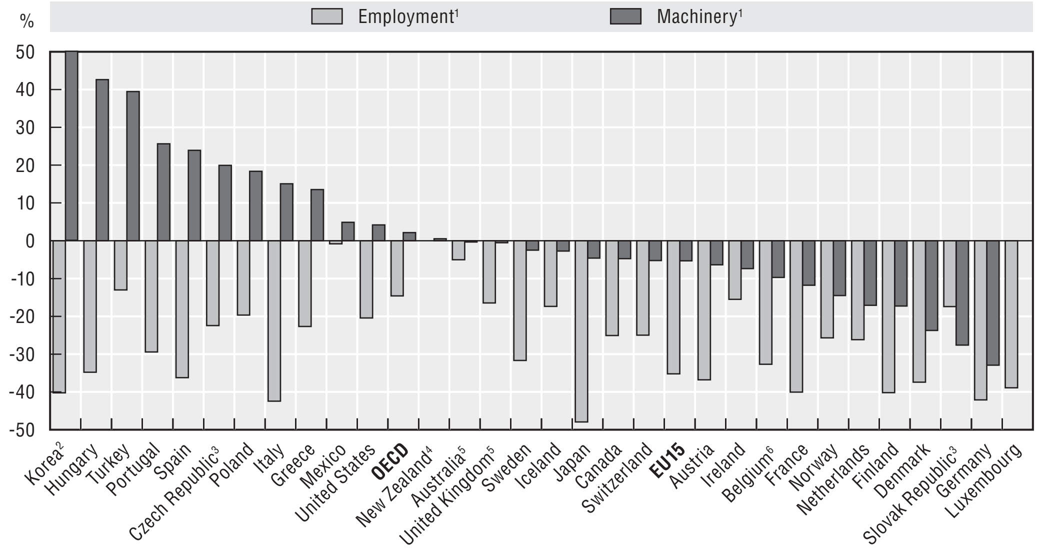
1. Data cover total on-farm energy consumption by primary agriculture (for irrigation, drying, horticulture, machinery and livestock housing), forestry, fishing and hunting.

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

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

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

1990-92 to 2002-04



StatLink http://dx.doi.org/10.1787/287016550645

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

Source: FAOSTAT (2007).

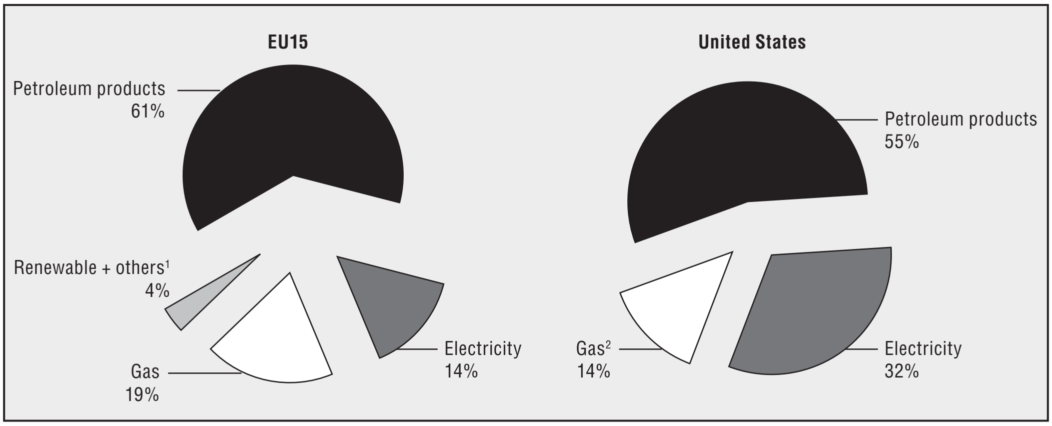
Petroleum products, mainly petrol and diesel, provide the main sources of on-farm energy consumption, accounting for over 50% in both the **EU15** and the **United States** (Figure 1.4.5), and over 80% in some countries (*e.g.* **Belgium**, **Ireland**, and **Portugal**). With the expansion in renewable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

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

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

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

2002



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

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

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

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

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

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

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1.5. SOIL

KEY TRENDS

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

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

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

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

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

Indicator definitions:

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

 ENVIRONMENTAL PERFORMANCE OF AGRICULTURE IN OECD COUNTRIES SINCE 1990 – ISBN 978-92-64-04092-2 – © OECD 2008

Concepts and interpretation

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

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

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

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

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

Recent trends

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

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

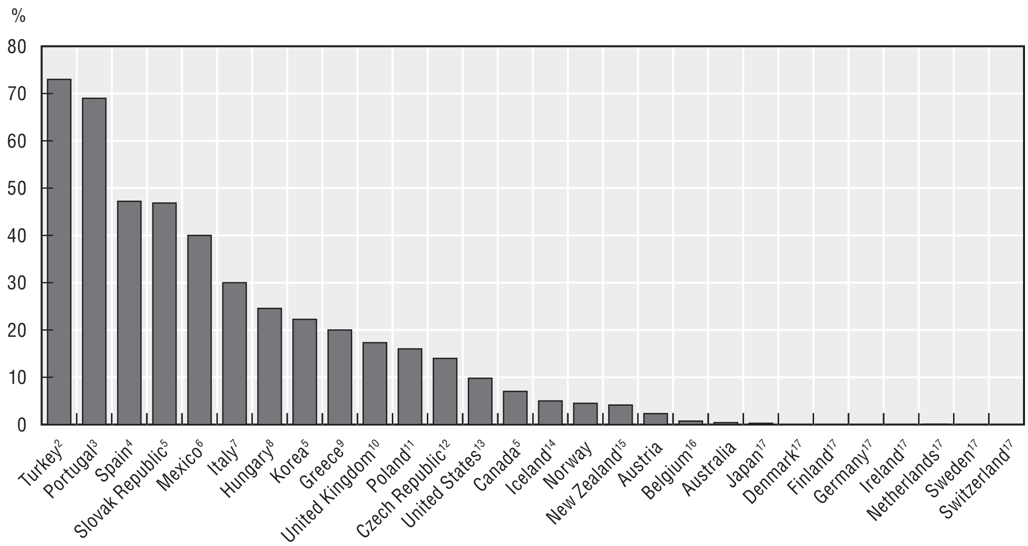
Soil erosion from water for most OECD countries shows that the major share of agricultural land is within the tolerable water erosion category and thus erosion is not considered a concern (Figure 1.5.1). Almost a third of OECD countries have more than 20% of agricultural land within the moderate to severe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

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

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

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

Average 2000-02



StatLink http://dx.doi.org/10.1787/287065145113

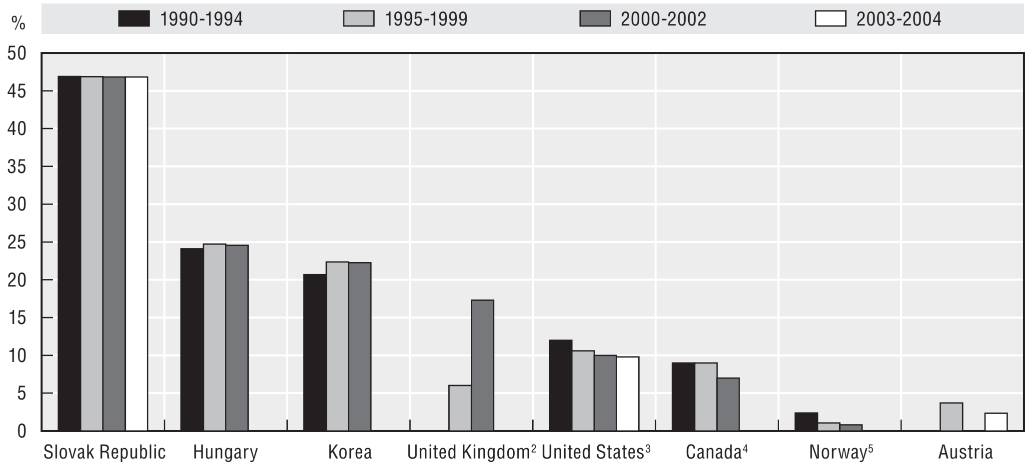
1. Risk of water erosion greater than 11 t/ha/y of soil loss, unless otherwise indicated.
2. Share of agricultural land of risk to elevated erosion rates, but t/ha/y not specified.
3. Covers all land including agricultural land, and covers high risks, but not defined source OECD (2001), Environmental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

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

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

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

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



StatLink http://dx.doi.org/10.1787/287073572653

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

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

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

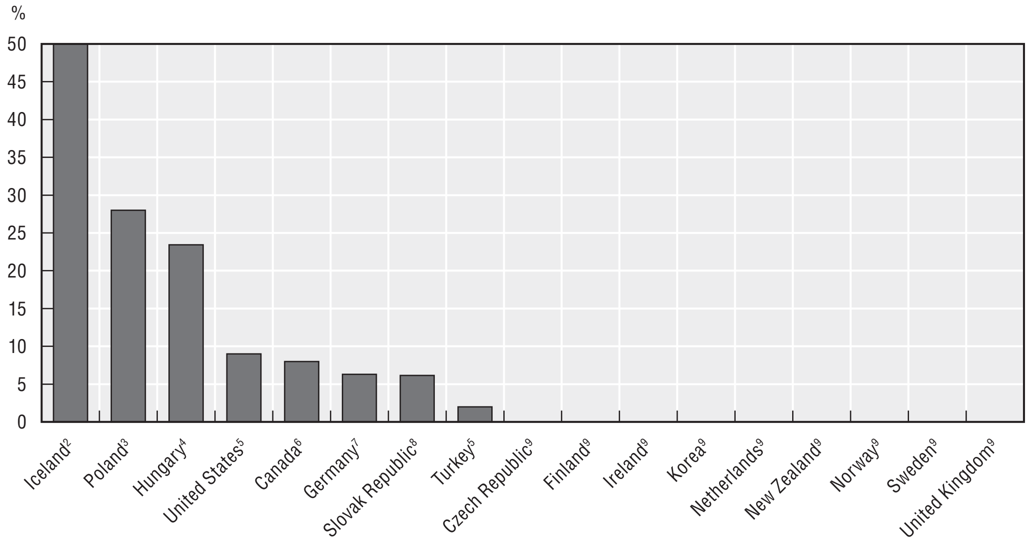
vegetation cover. While other parts of Europe are less prone to severe cases of erosion, there is concern over erosion risks from water and wind in central Europe (the **Czech** and **Slovak Republics, Hungary, Poland**) and wind erosion in **Iceland** (Figures 1.5.1-1.5.3). Evidence for these countries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

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

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

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

Average 2000-04



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

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

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

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

For **Australia**, evidence from the late 1990s suggests that there may be some reduction in soil erosion rates (Hamblin, 2001). But, in 1999, some 11% of farmers experienced significant soil degradation caused by water erosion and 2% encountered severe wind erosion, while on average, 90% of Australia's soil erosion from agriculture comes from 20% of the agricultural land area (National Land and Water Resources Audit, 2002). Farming practices have exacerbated the extent and rate of soil degradation with up to a third of the total area of rangeland showing acute symptoms of soil degradation, and 50-65% of crop land at risk in any one season from wind erosion. Soil erosion studies in Australia have revealed high costs, estimated annually at AUD 80 million (USD 45 million) in infrastructure repairs and AUD 450 million (USD 250 million) in water quality contamination as the result of soil erosion (Chapter 3). However, problems of soil degradation through salinity, acidity and sodicity are a much greater problem in Australia than soil erosion (Chapter 3).

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

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

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1.6. WATER

KEY TRENDS

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

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

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

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

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

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

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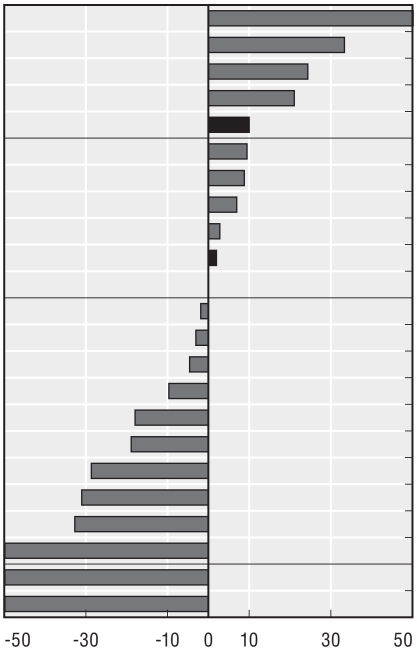
Figure 1.6.1. **Agricultural water use**[1]

% change in total agriculture water use 1990-92 to 2001-03



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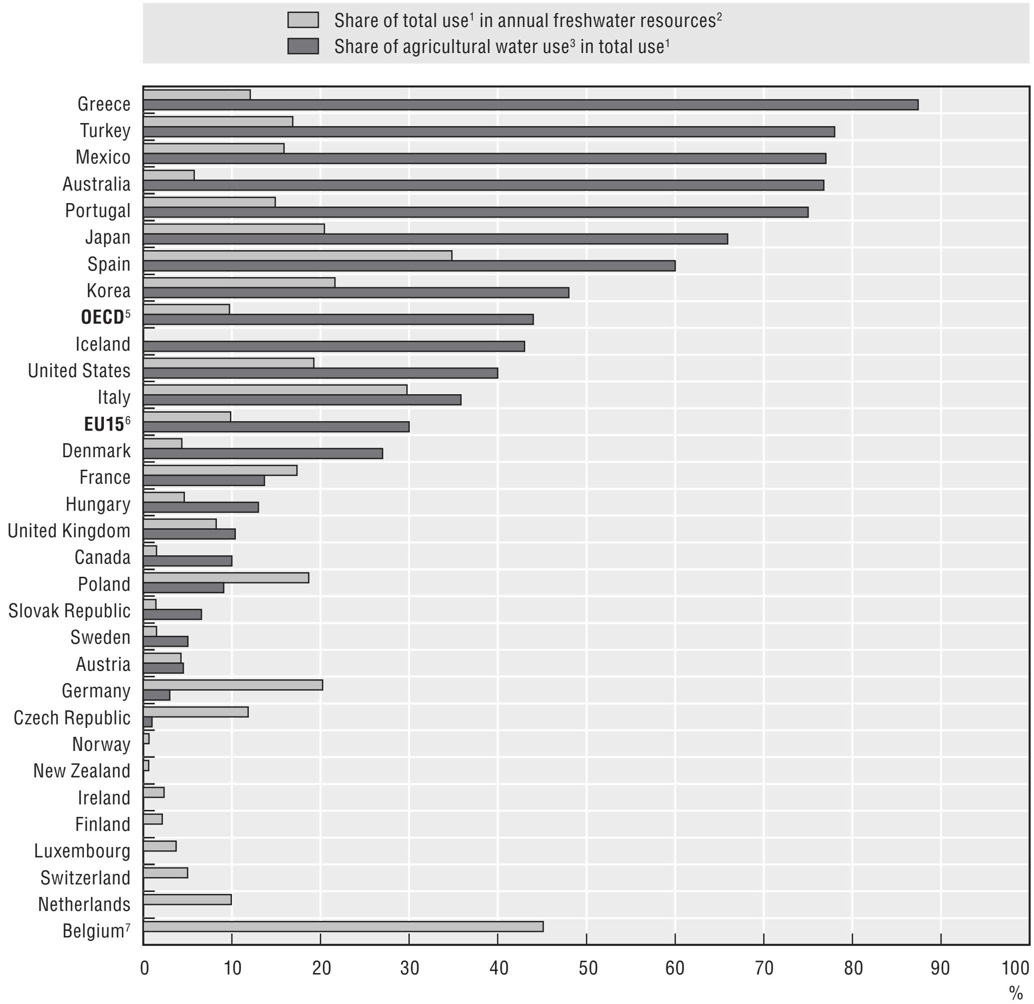
1. Agricultural water use is defined as water for irrigation and other agricultural uses such as for livestock operations. It includes water abstracted from surface and groundwater, and return flows from irrigation but excludes precipitation directly onto agricultural land.
2. Total water use is the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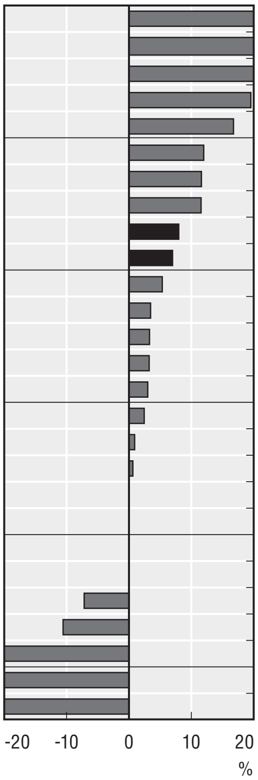
1. Total use (abstractions) of water by all users, including public water supply, agriculture, industry, and for power station cooling.
2. Annual freshwater resources include: Mean annual precipitation + transborder water flows – mean annual evapotranspiration (over-exploitation of groundwater resources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

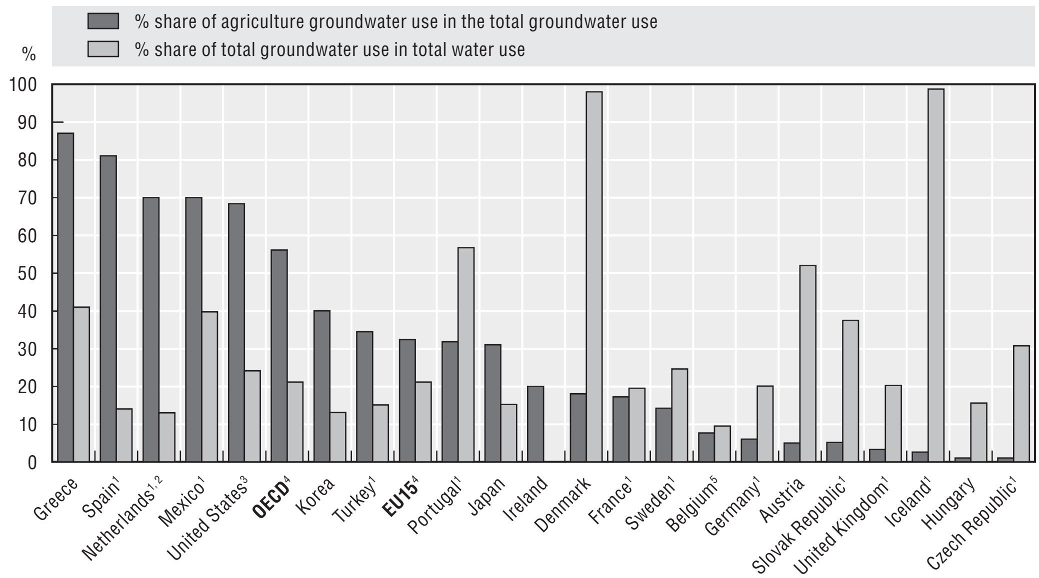
Trends and projections in agricultural water use are of particular concern for groundwater resources. Agriculture's share in total groundwater utilisation is above 30% in a third of OECD countries (Figure 1.6.4). While there is little cross country OECD data on trends in agricultural groundwater use,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

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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).

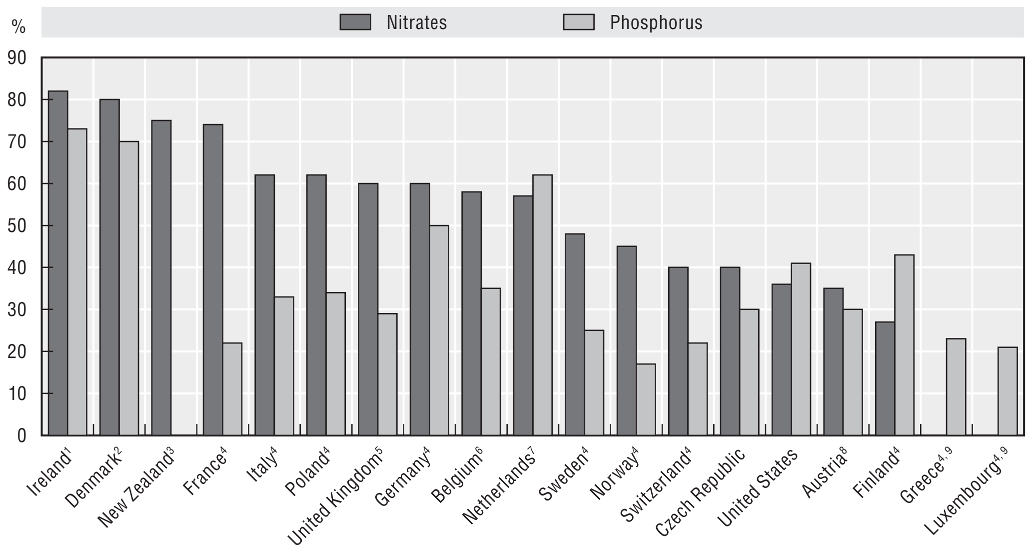
The economic cost of agricultural water pollution is high in many cases. Treating water to remove nutrients and pesticides to ensure water supplies meet drinking standards is significant in some OECD countries. In the **United Kingdom**, for example, the overall economic cost of water pollution from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



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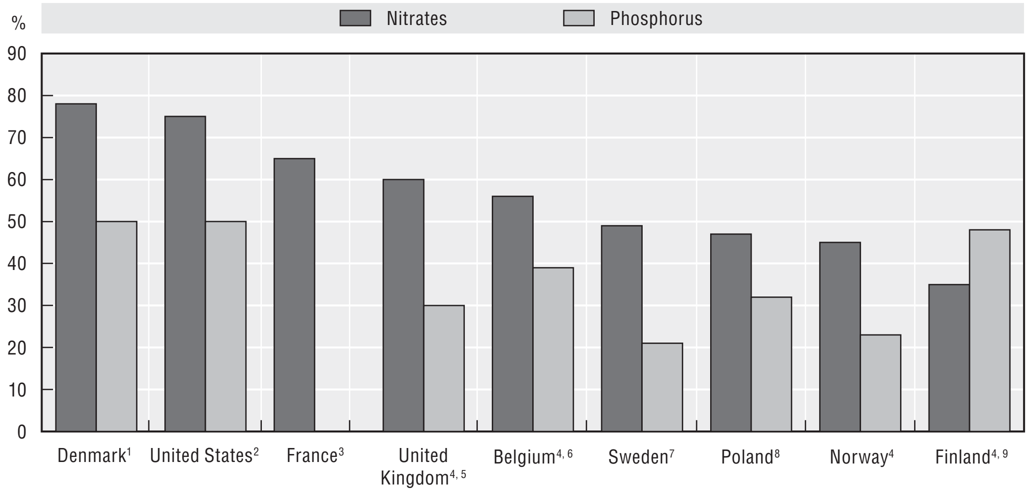
1. 2004, see Ireland, Chapter 3.
2. Phosphorus (2002), percentage refers to Danish lakes only.
3. Data for nitrate contamination of rivers and streams, total input to surface waters from agriculture non-point source pollution. Data for phosphorus not available. *Source:* New Zealand Parliamentary Commissioner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

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

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

Average 2000-02



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

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

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

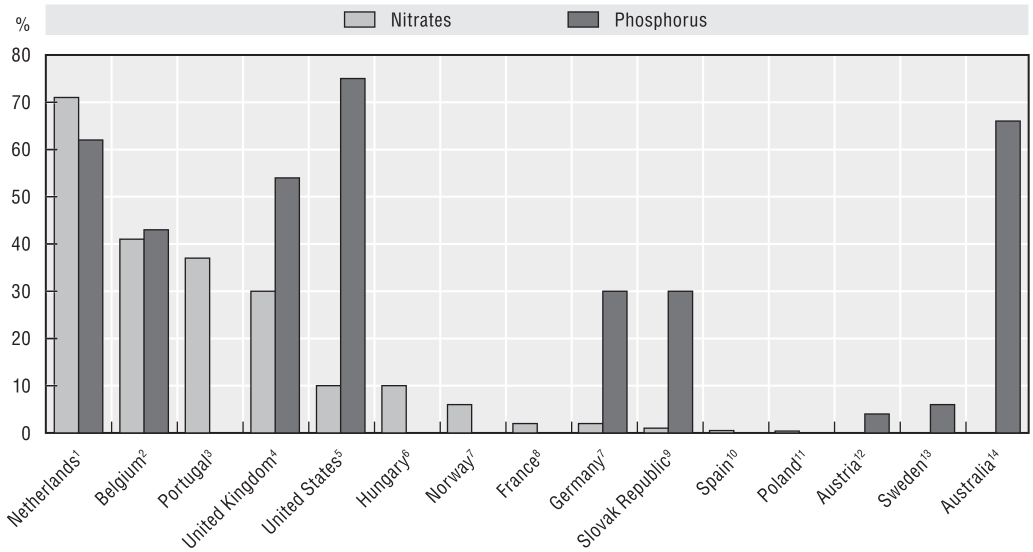
(Figure 1.6.6). But the share of agricultural nitrates in surface and coastal waters can reveal significant fluctuations depending on annual river flows, such as in the **United Kingdom** (Chapter 3).

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

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

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

Average 2000-02



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

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

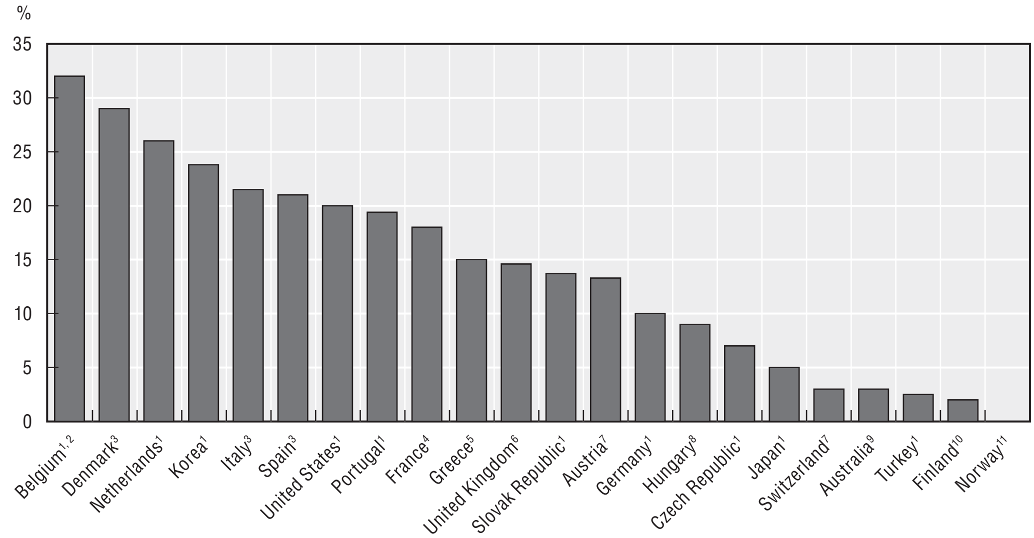
Source: OECD Agri-environmental Indicators Questionnaire, unpublished; OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France.

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

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

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

Average 2000-04



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

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

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

Phosphorus

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

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

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

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

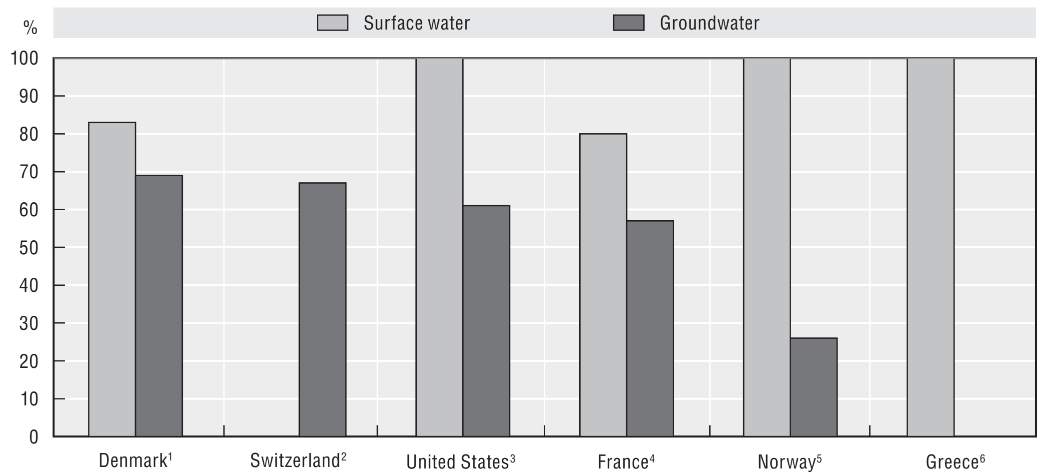
Pesticides

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

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

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

Average 2000-03



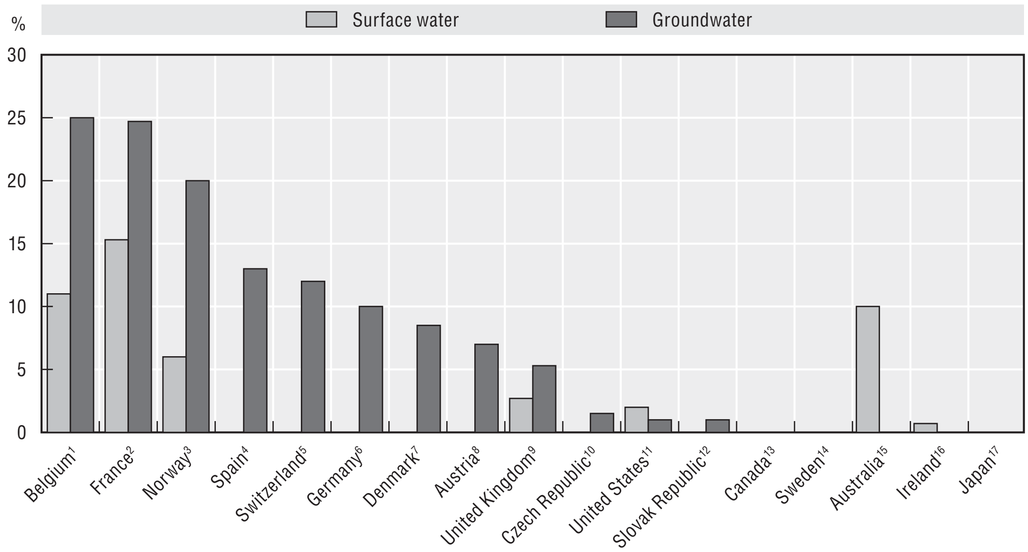
StatLink http://dx.doi.org/10.1787/287348331384

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

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

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

Average 2000-02



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

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

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

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

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

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

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1.7. AIR

KEY TRENDS

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

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

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

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

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

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

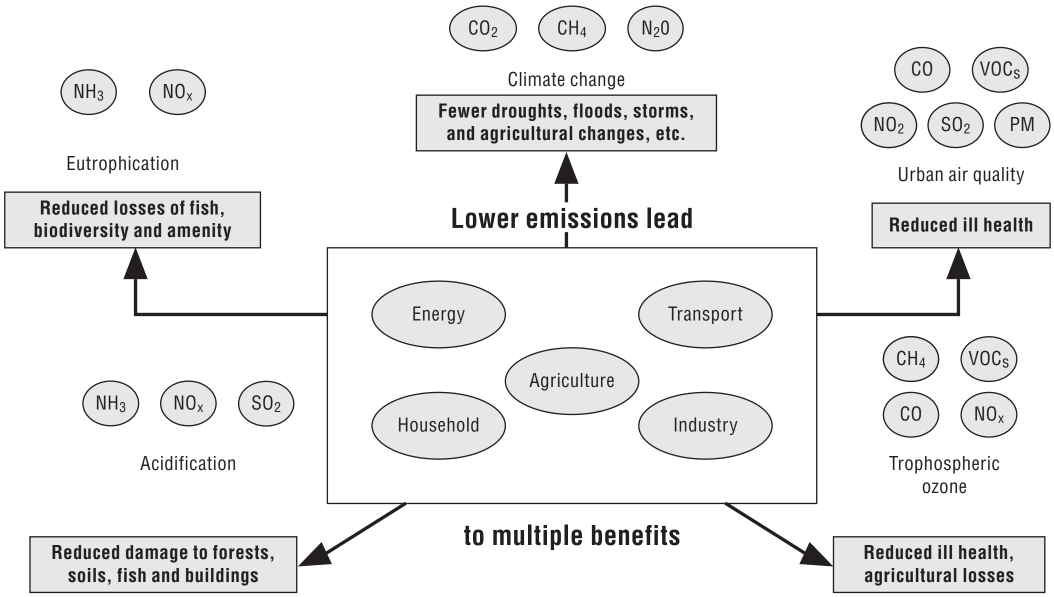
The largest increase in agricultural GHG emissions (over 5%) occurred in Australia, Canada, New Zealand, Portugal and Spain, which together increased GHG emissions by 26 million tonnes CO_2 equivalent, and now these countries account for over 20% of total OECD agricultural GHG emissions. But for the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

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

Background

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

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



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

Source: EEA (2000).

1.7.1. Ammonia emissions, acidification and eutrophication

Indicator definition:

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

Concepts and interpretation

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

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

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

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

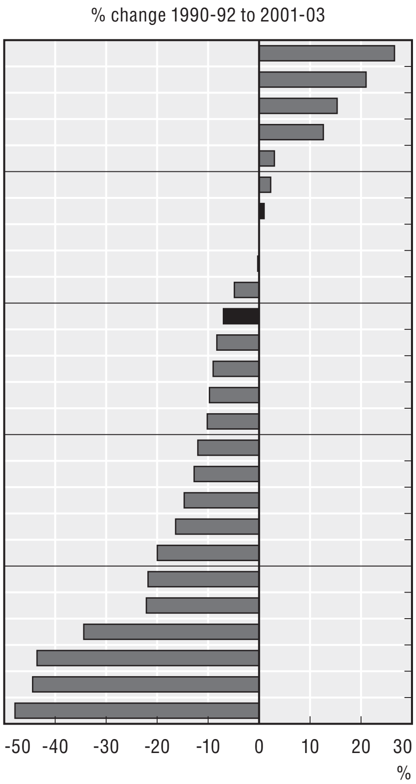
The agricultural ammonia emission indicator is linked to trends in nitrogen balances (Section 1.2) as ***driving forces*** on the ***state*** or concentrations of *nitrates in water bodies* (Section 1.6.2) and acidifying pollutants in the air. The agriculture sector in many OECD countries is obliged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

Recent trends

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

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

Figure 1.7.2. **Ammonia emissions from agriculture**



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

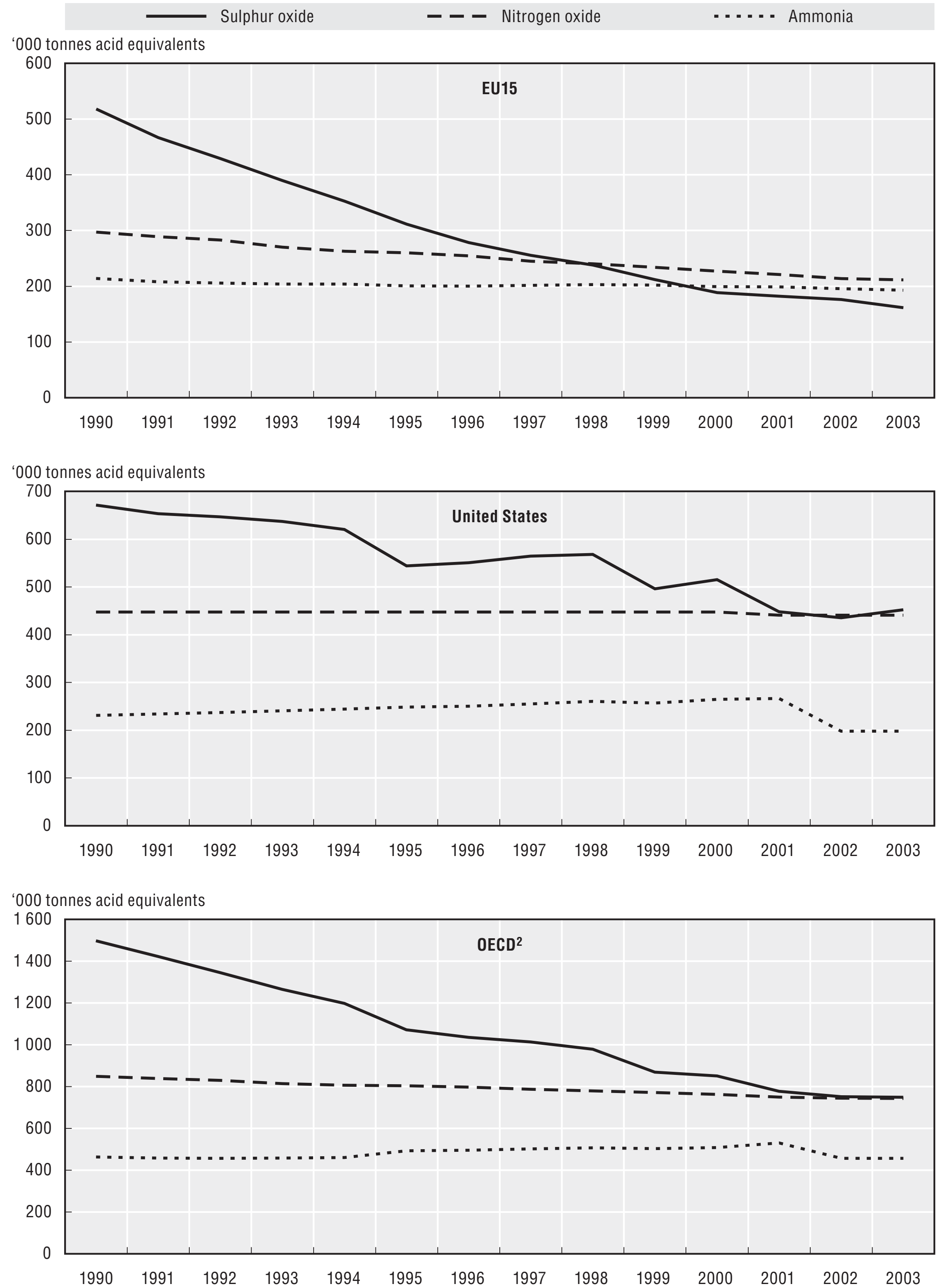
StatLink http://dx.doi.org/10.1787/287442521548

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

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

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

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



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

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

Source: EMEP (2006).

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

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

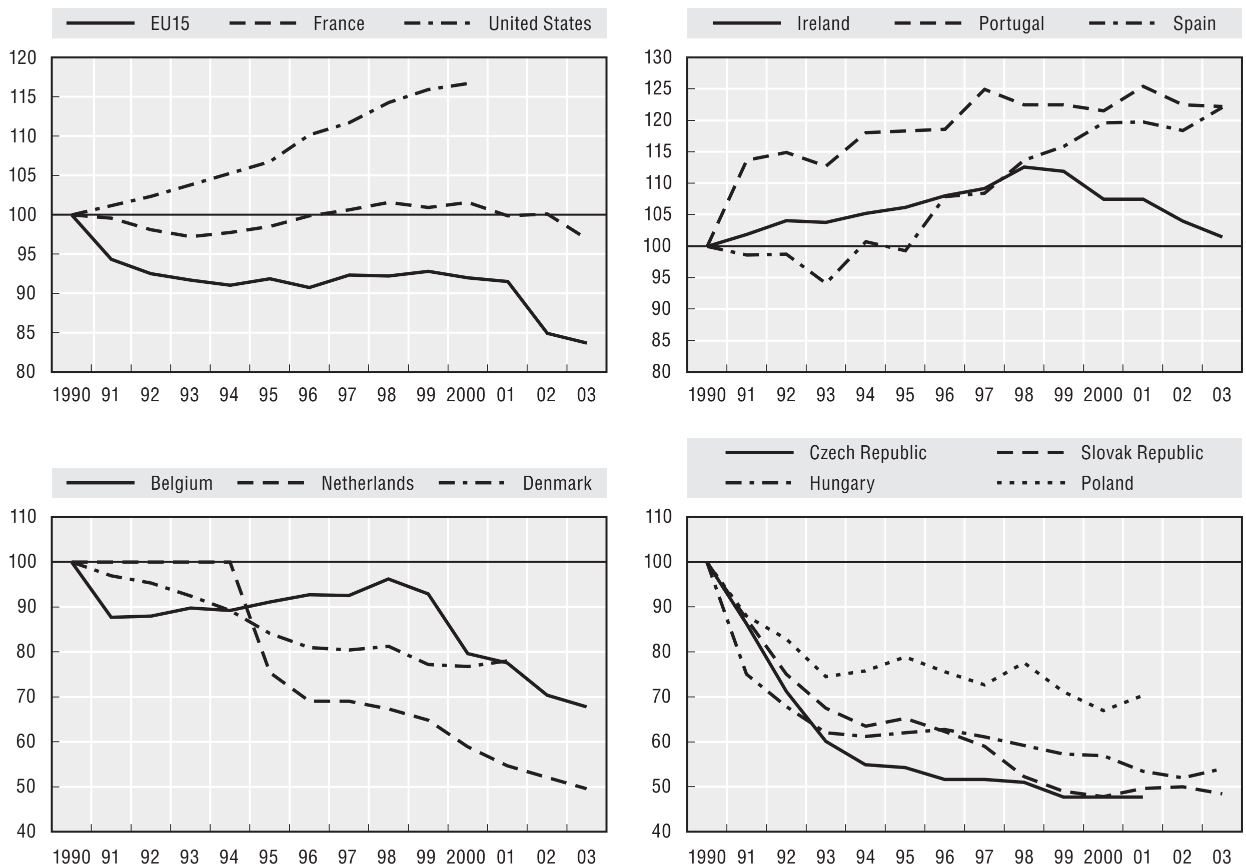
StatLink http://dx.doi.org/10.1787/301400303071

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

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

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

1990 = 100



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Source: EMEP (2006).

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

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

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

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

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

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

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

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

StatLink http://dx.doi.org/10.1787/301407730631

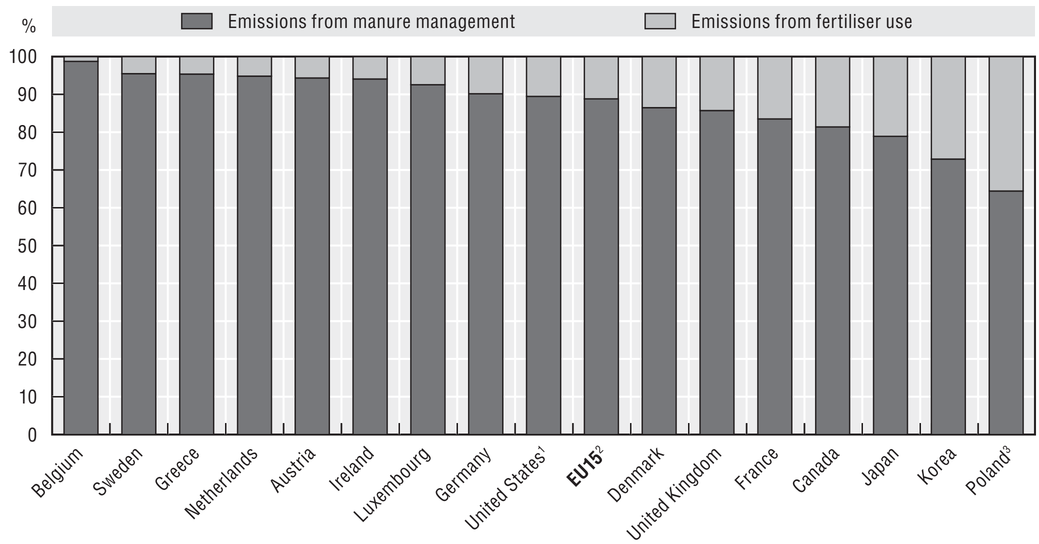
1. The following countries are not signatories to the LRTAP: Australia, Iceland, Korea, Japan, Mexico and New Zealand.
2. See notes, Figure 1.7.2, concerning national averages used for 2001-03.
3. This column shows, for each respective country, the extent to which emissions in 2001-03 were below the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

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

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

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

Mid-1990s



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

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

1.7.2. Methyl bromide use and ozone depletion

Indicator definition:

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

Concepts and interpretation

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

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

The Parties to the *Montreal Protocol on Substances that Deplete the Ozone Layer* agreed in 1997 to a global phase-out schedule for methyl bromide. Under the schedule, developed countries had to reduce methyl bromide use by 25% by 1999, 50% by 2001, 70% by 2003 and 100% by 2005, compared to 1991 levels. Developing countries (*i.e.* Article 5 member countries under the *Montreal Protocol*), which have contributed less to ozone depletion, started a freeze on use in 2002 at average 1995-98 levels, and need to achieve a 20% reduction by 2005 and 100% by 2015 (UNEP, 2004a). Among OECD countries, **Korea**, **Mexico** and **Turkey** are included under Article 5 of the *Montreal Protocol*.

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

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

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

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

Recent trends

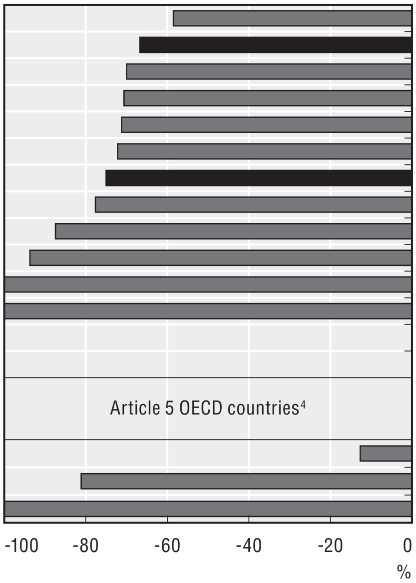
All OECD countries achieved the reduction level targets for methyl bromide specified under the *Montreal Protocol* up to 2003 (Figure 1.7.6; Table 1.7.3). But in 2004 there was a nearly 30% rise in the overall OECD methyl bromide use compared to 2003, largely accounted for by greater use in the **United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

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

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

Figure 1.7.6. **Methyl bromide use**

Percentage change in tonnes of ozone depleting potential (ODP tonnes) 1991 to 2004



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

StatLink http://dx.doi.org/10.1787/287574280471

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

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

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

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

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

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

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

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

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

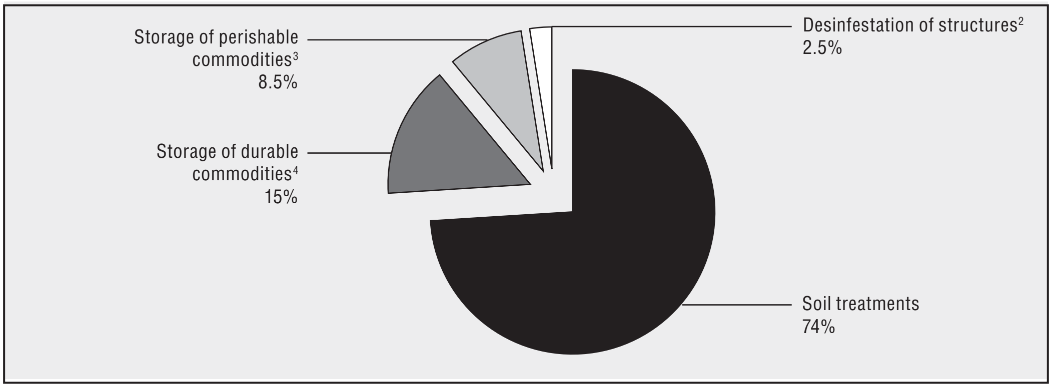
Source: OECD Secretariat, based on UNEP (2006).

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

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

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

2000 estimate[1]



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

Source: UNEP (2002).

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

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

StatLink http://dx.doi.org/10.1787/301461058717

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

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

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

1.7.3. Greenhouse gas emissions and climate change

Indicator definition:

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

Concepts and interpretation

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

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

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

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

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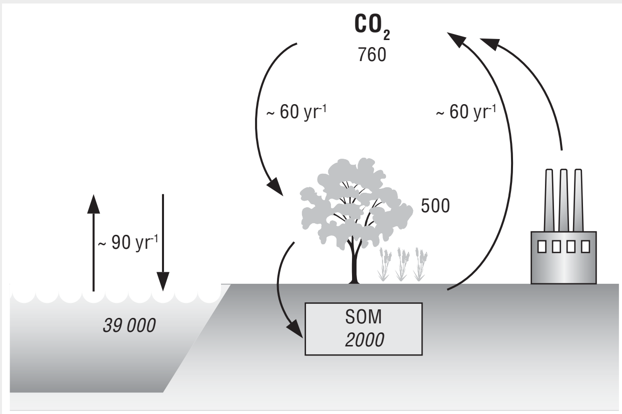
Box 1.7.1. **Towards a net agricultural greenhouse gas balance indicator?**

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



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

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

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

Recent trends

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

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

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

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

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

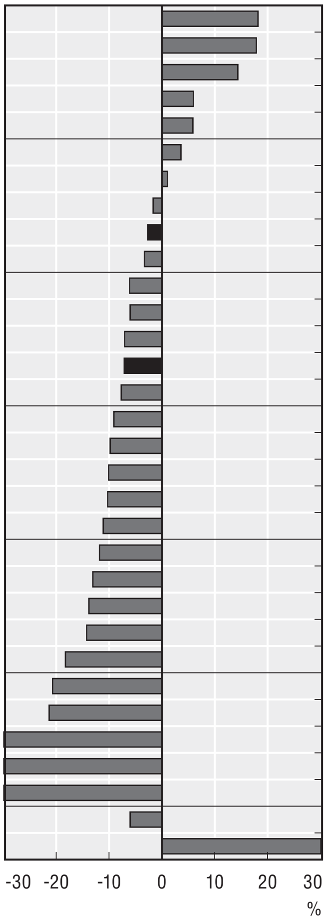
Carbon dioxide equivalent: 1990-92 to 2000-02

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

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

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

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



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

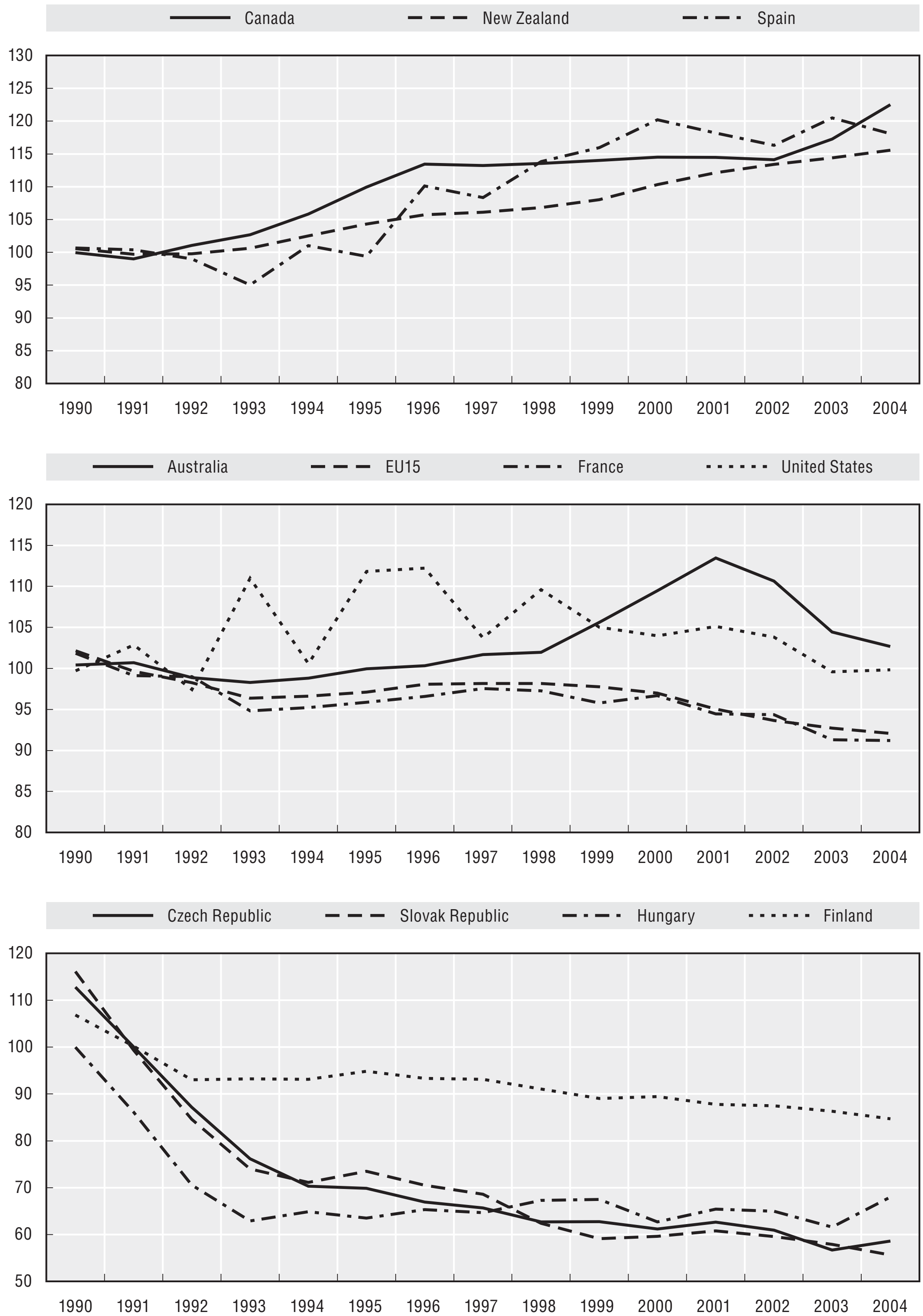
StatLink http://dx.doi.org/10.1787/287608012166

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

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

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

Average 1990-92 = 100



StatLink http://dx.doi.org/10.1787/287622362584

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

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

1990-92 to 2000-02

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

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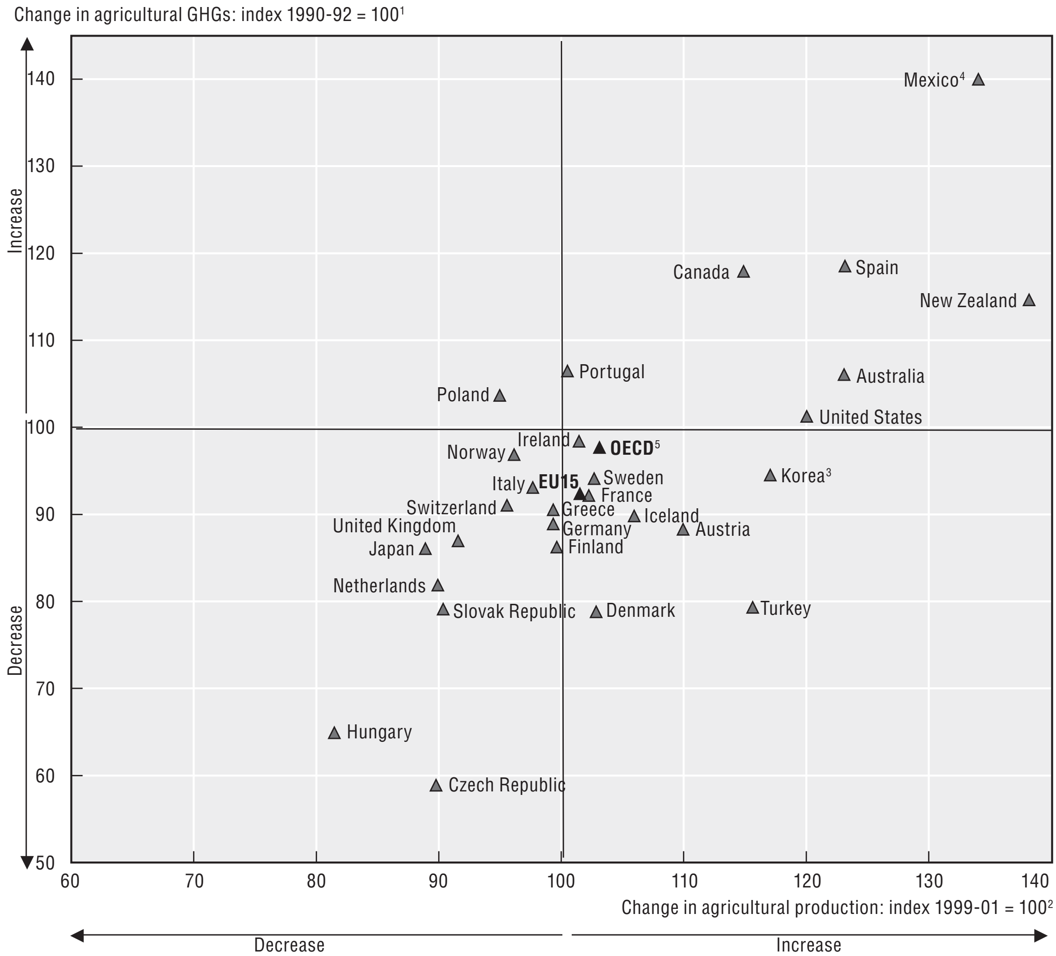
n.a.: Not available.

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

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

Figure 1.7.10. **Agricultural production and agricultural greenhouse gas emissions**

Change in index 1990-92 to 2002-04



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

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

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

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

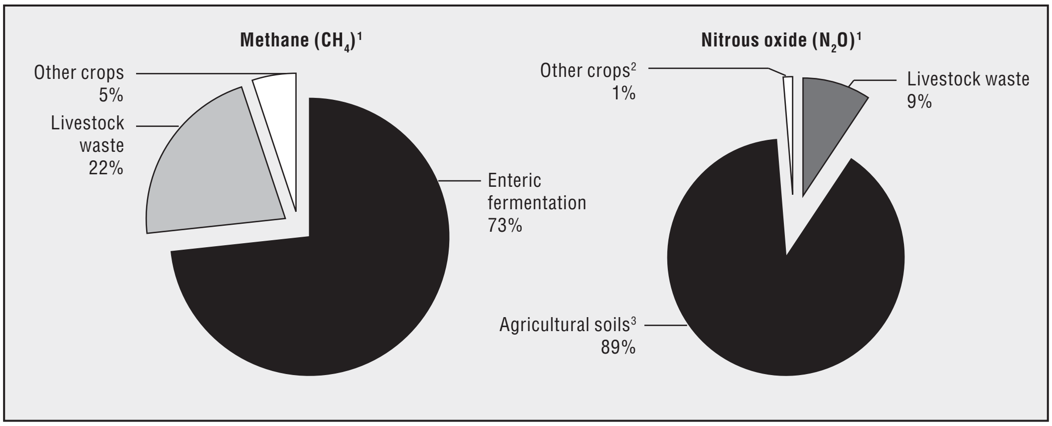
The share of agriculture in total **carbon dioxide** emissions is around 1% which largely originates from fuel combustion linked to the use of farm machinery and in heating livestock and horticultural housing. However, although the share of total agricultural GHG emissions is relatively small in total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

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

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

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

2000-02



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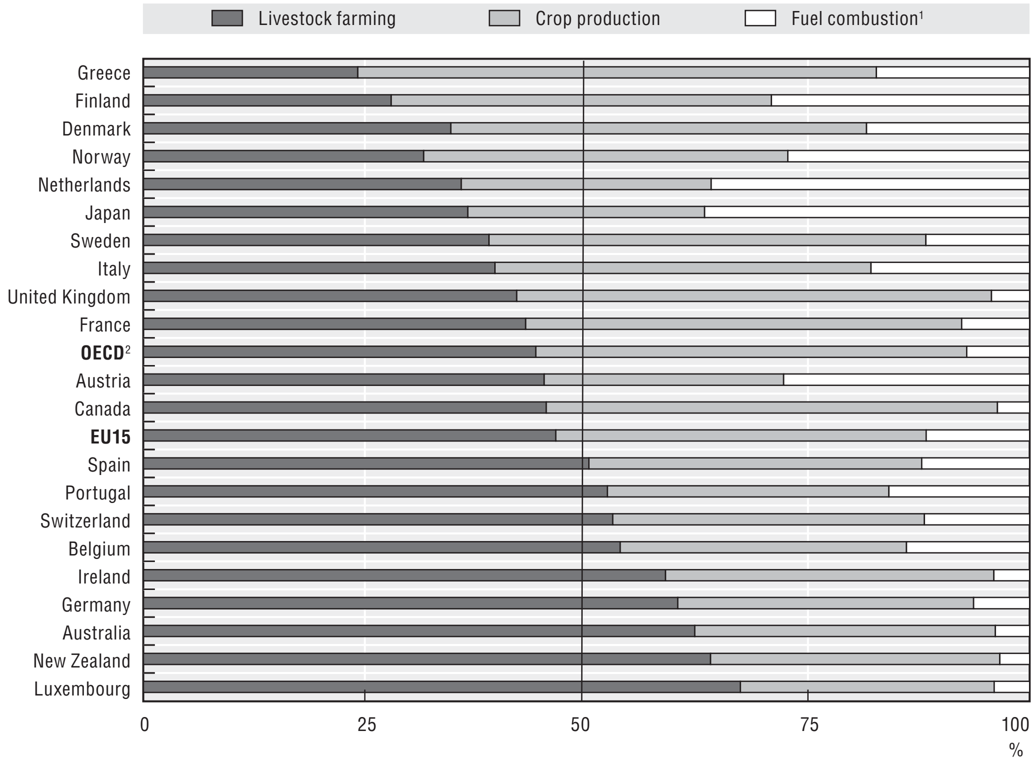
1. Data may not add to total due to rounding areas.
2. Other crops include grassland, rice and crop residue burning for CH_4 and grassland and crop residue burning for N_2O, respectively.
3. Mainly emissions from the application of fertilisers.

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

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

2000-02



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

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

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

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1.8. BIODIVERSITY

KEY TRENDS

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

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

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

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

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

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

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

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

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

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

Background

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

Box 1.8.1. **Defining agricultural biodiversity**

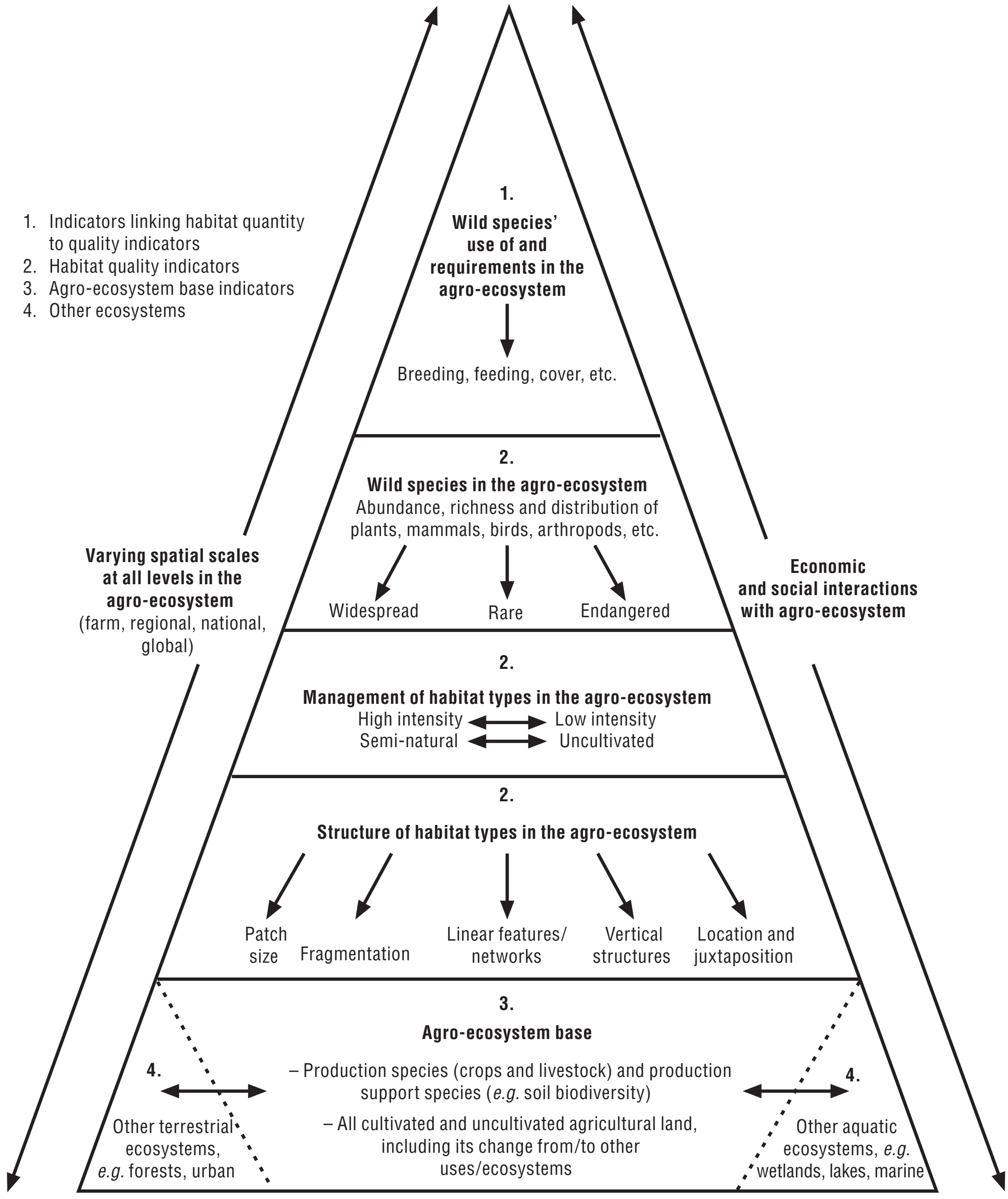
Drawing on the CBD definition of biodiversity, agricultural biodiversity in this report is defined in terms of three levels (OECD, 2001):

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

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

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

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



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Source: OECD (2003a).

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

1.8.1. Genetic diversity

Indicator definitions:

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

Concepts and interpretation

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

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

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

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

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

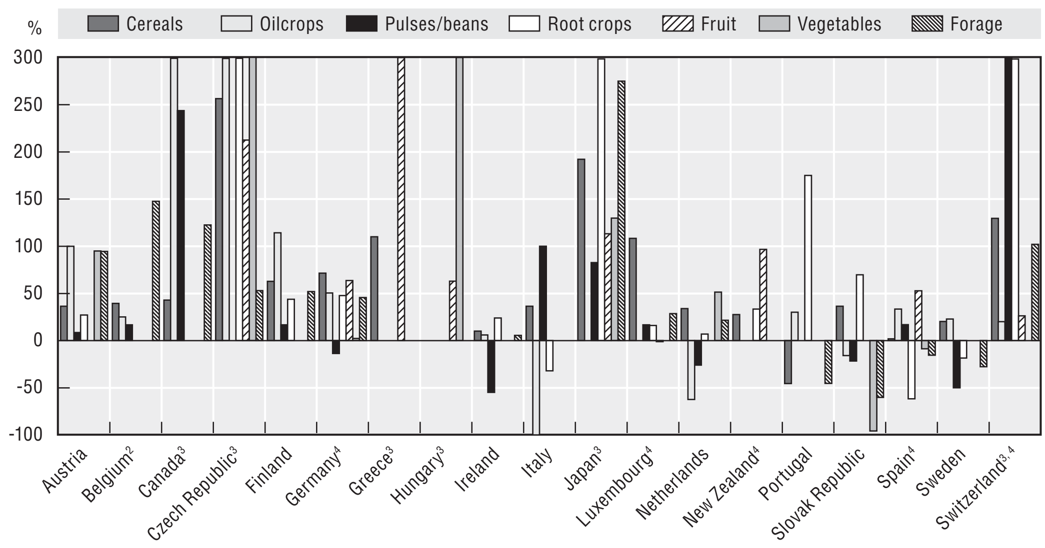
Overall changes in farming practices and systems (Section 1.9) are the key ***driving forces*** that link to the ***state*** of AGR diversity and ***responses*** in terms of national conservation programmes and in terms of areas under agri-biodiversity management plans (Section 1.9). There are also links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

Recent trends

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

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

% change 1990 to 2002



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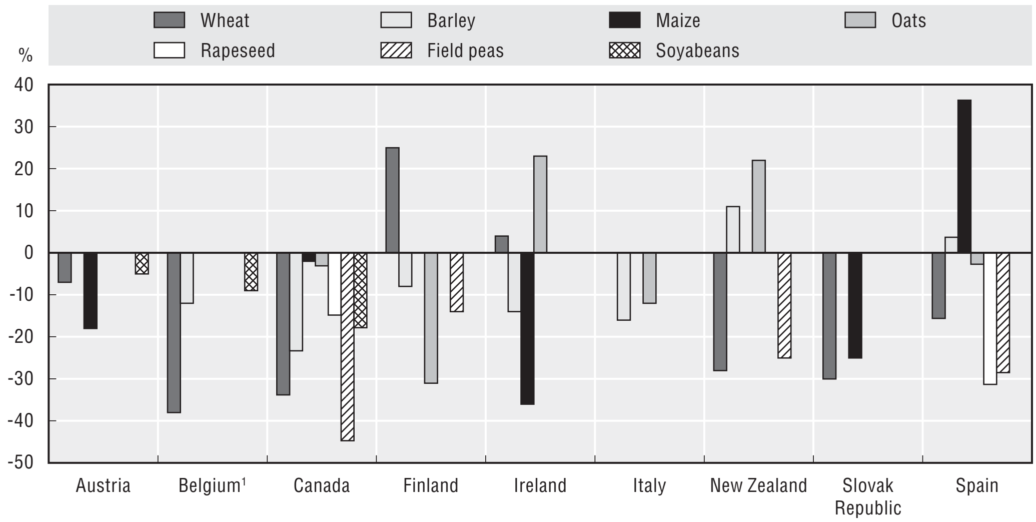
1. Industrial crop data are not included, because data are not available for many countries.
2. Data for 1990 and 2001 include only Flanders.
3. For Canada, the figure for oilcrops is 633%. For the Czech Republic, the figure for oilcrops is 486%; for root crops, 418%; and for vegetables, 307%. For Greece,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

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

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

% change 1990 to 2002



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

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

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

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

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

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

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

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

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

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

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

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

2004

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

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

2004

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

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

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

Source:

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

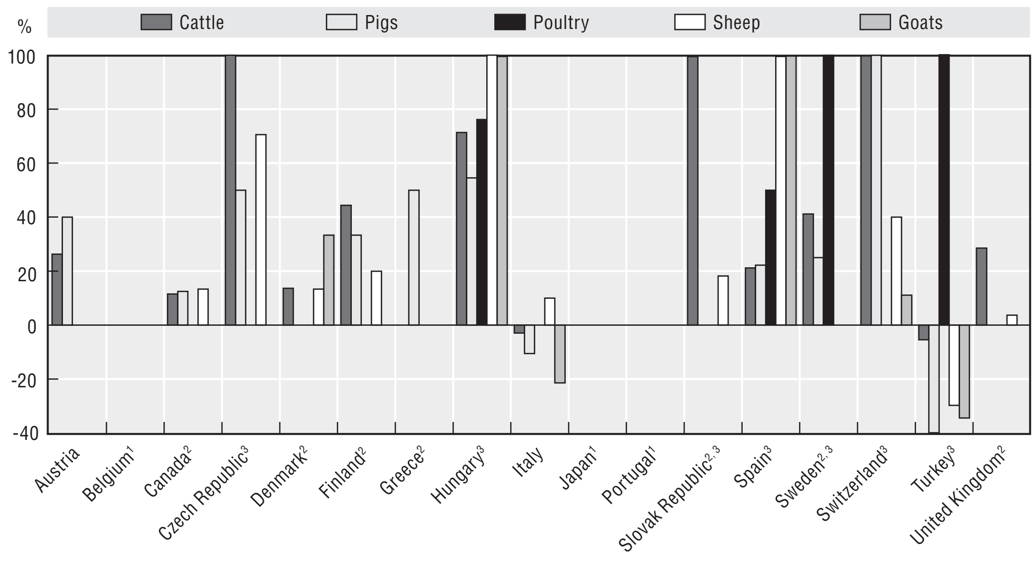
accessions (FAO, 1996). The **United States** has one of the world's largest collections of plant samples in its genebanks and conserves almost half a million different samples, distributing more than 100 000 samples annually.

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

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

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

% change 1990-2002



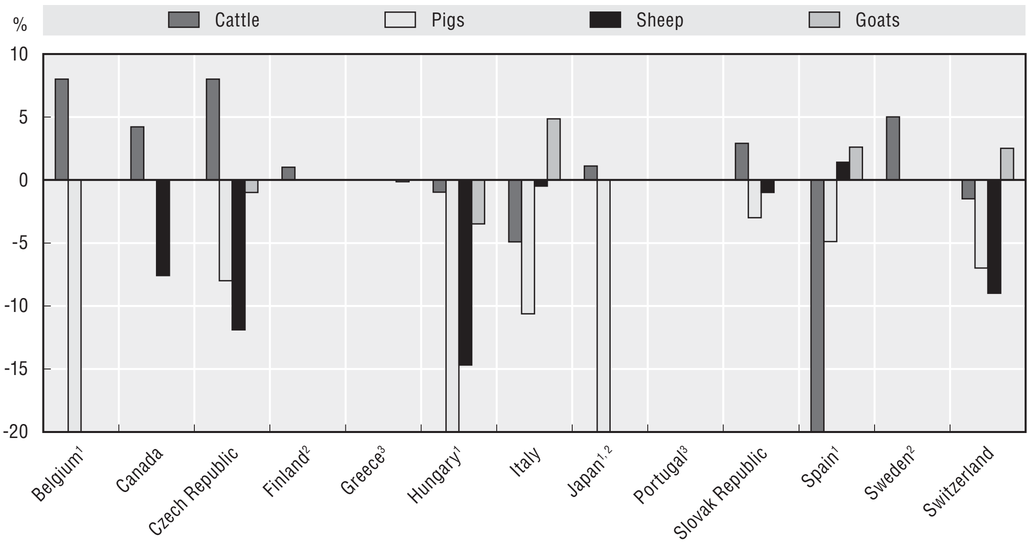
StatLink http://dx.doi.org/10.1787/288005800684

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

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

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

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



% share in 2002

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

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

n.a.: Not available.

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

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

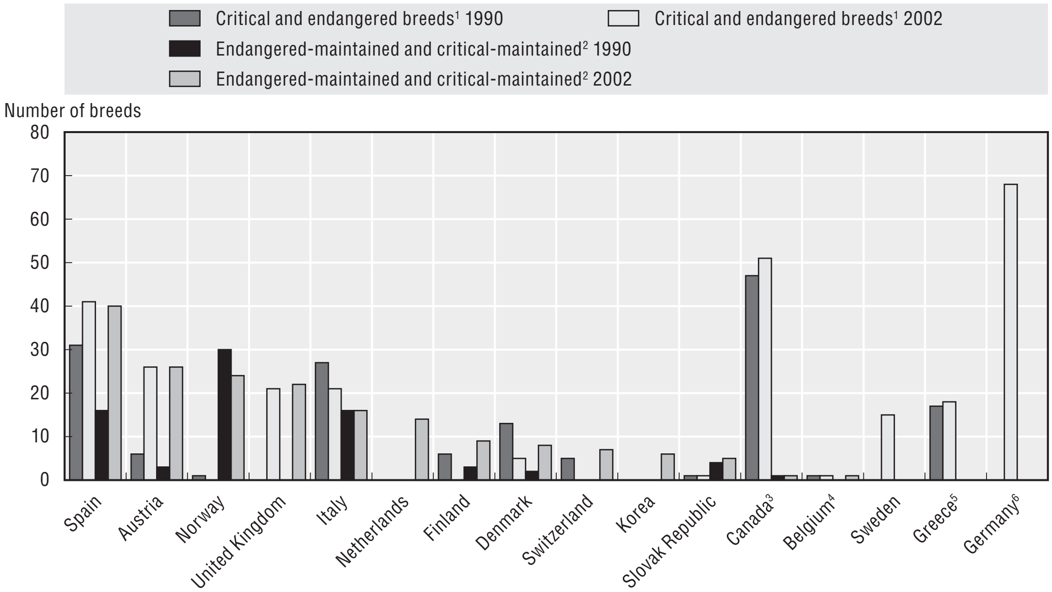
Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

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

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

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

1990 and 2002



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

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

n.a.: Not available.

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

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

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

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

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

2004

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

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

2004

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

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

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

Source:

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

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

1.8.2. Wild species diversity

Indicator definitions:

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

Concepts and interpretation

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

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

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

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

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

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

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

Recent trends

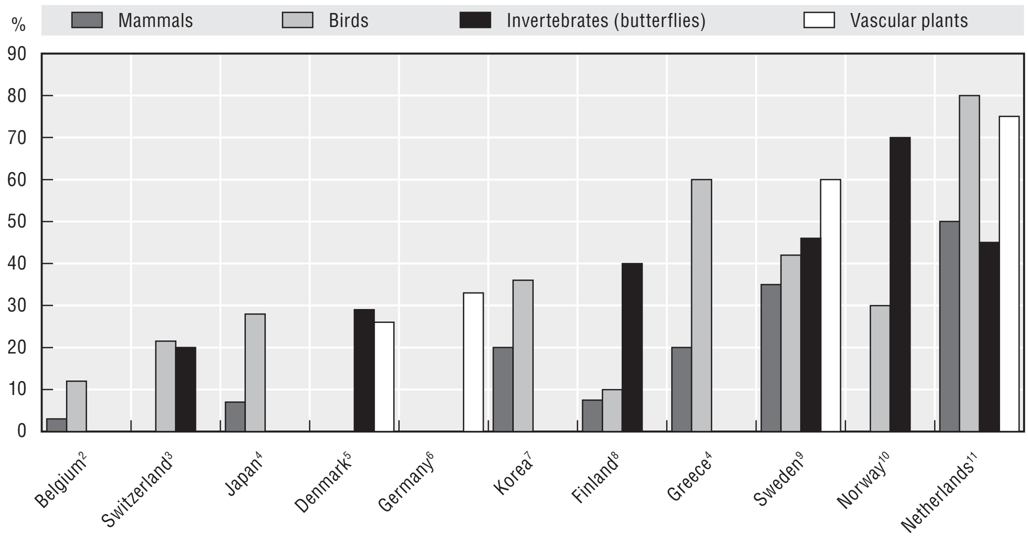
In many OECD countries agriculture is a major primary habitat for certain populations of wild species, and provides habitat for the remaining species following the conversion of "natural" habitat to farmland (Figure 1.8.7). This is particularly the case for birds and to a lesser extent butterflies, but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

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

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

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

Late 1990s/early 2000s



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

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

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

Source: OECD Agri-environmental Indicators Questionnaires, unpublished.

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

1.8.3. Ecosystem diversity

Indicator definitions:

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

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

2000 = 100[1]

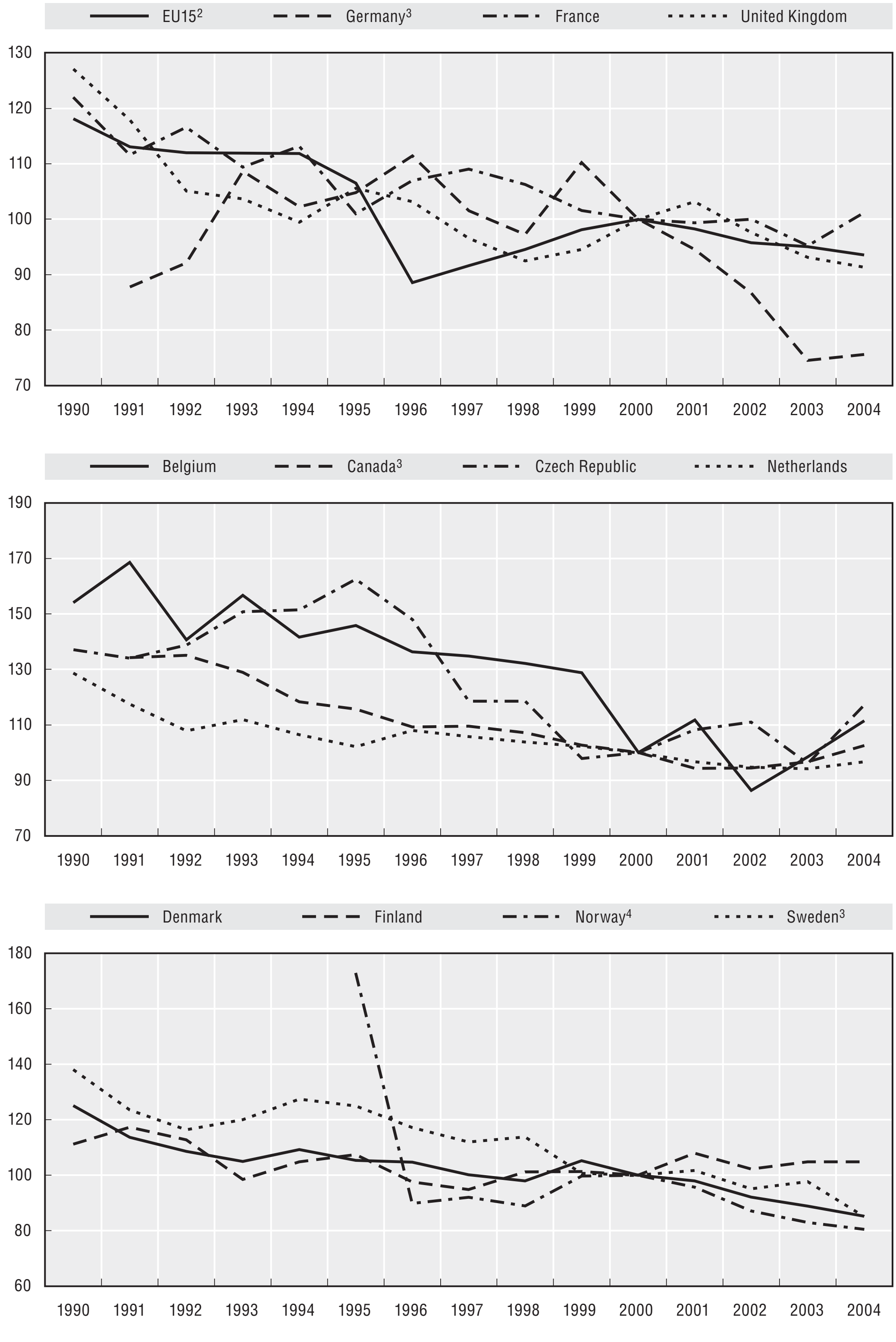
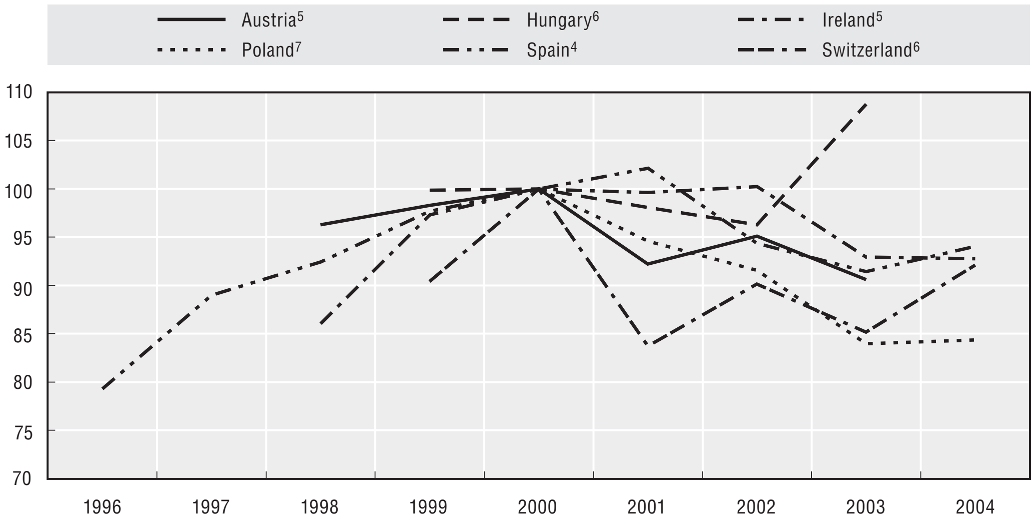


Figure 1.8.8. **Population trends of farmland birds** *(cont.)*

2000 = 100[1]



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

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

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

Concepts and interpretation

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

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

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

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

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

Recent trends

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

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

1985-2003[1]

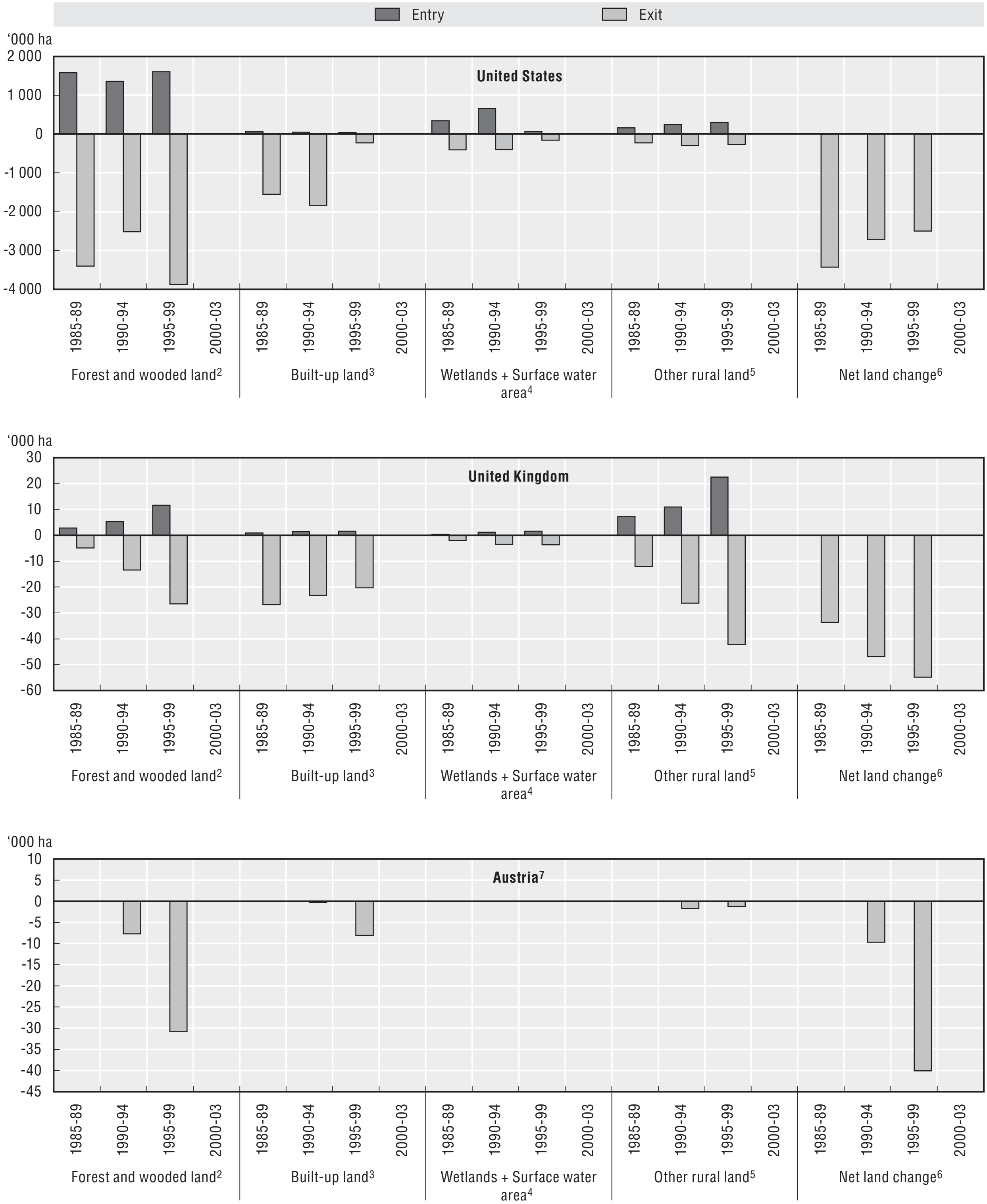


Figure 1.8.9. **Change in agricultural land use and other uses of land**[1] *(cont.)*

1985-2003[1]

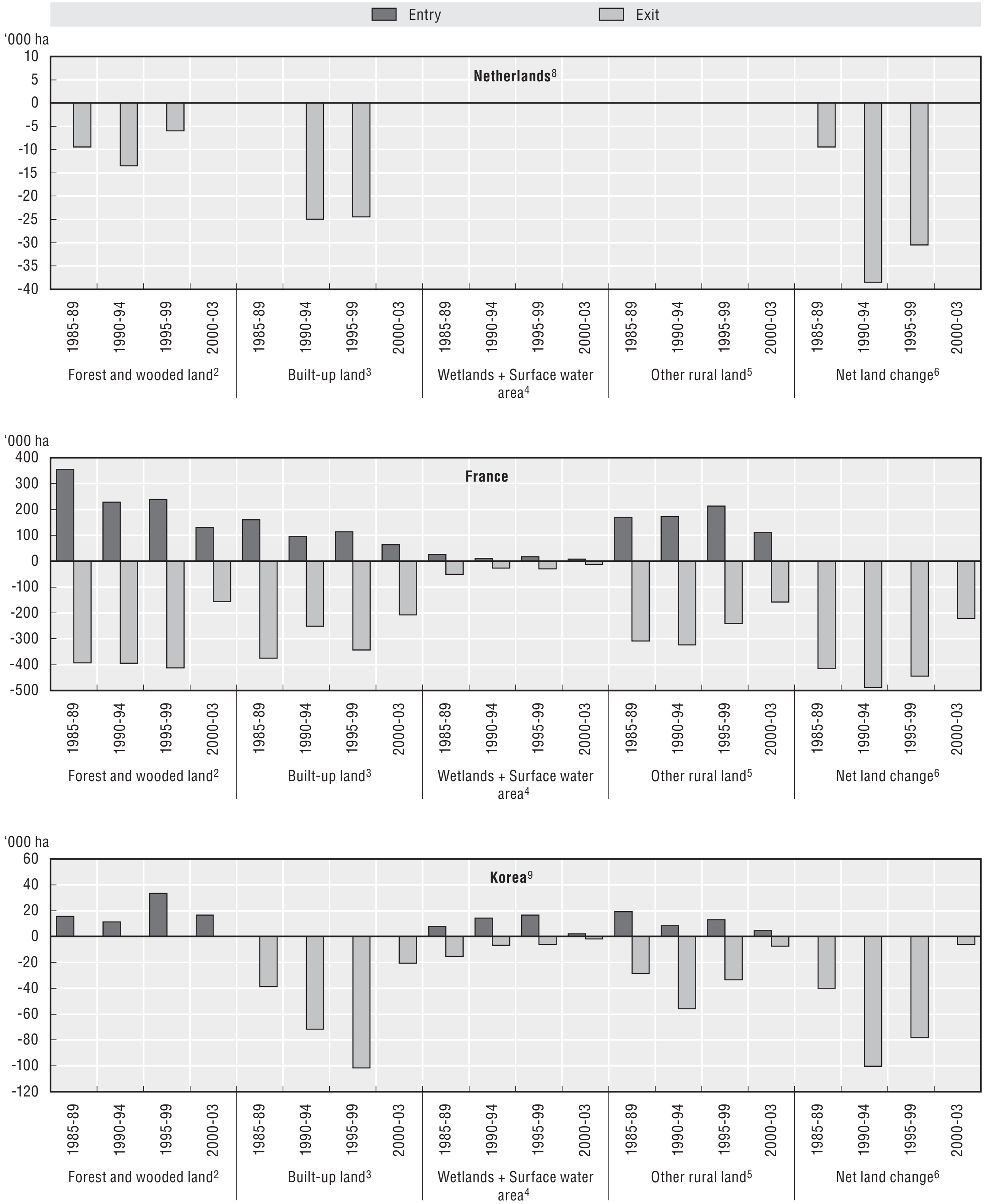
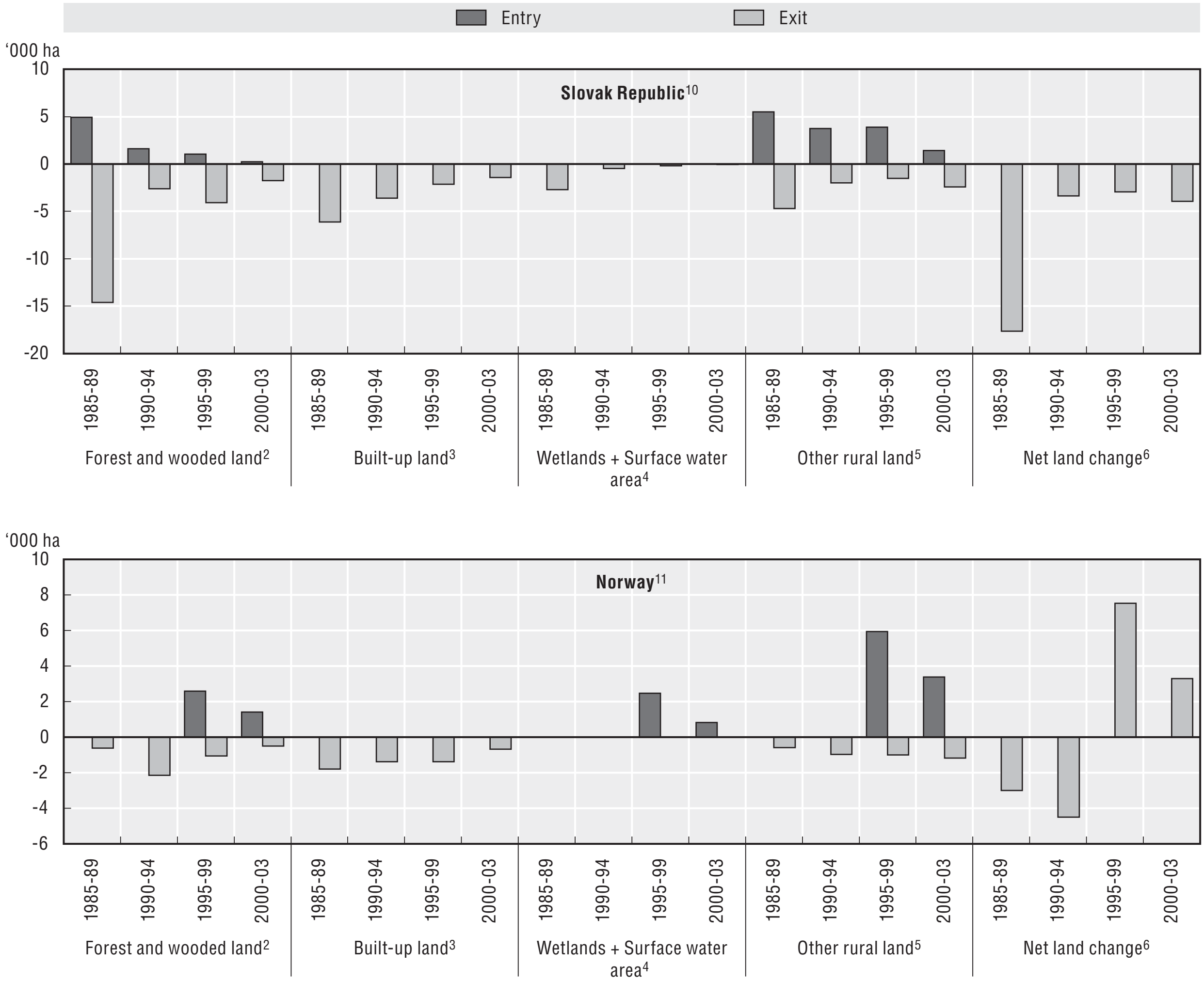


Figure 1.8.9. **Change in agricultural land use and other uses of land**[1] *(cont.)*

1985-2003[1]



StatLink http://dx.doi.org/10.1787/288072584130

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

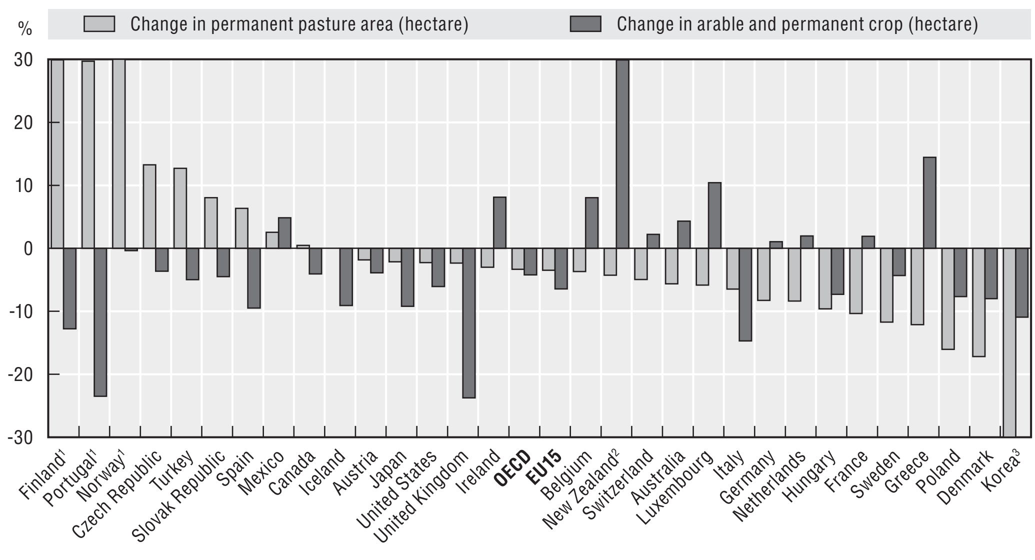
Source: OECD Secretariat; national data.

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

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

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

1990-92 to 2002-04



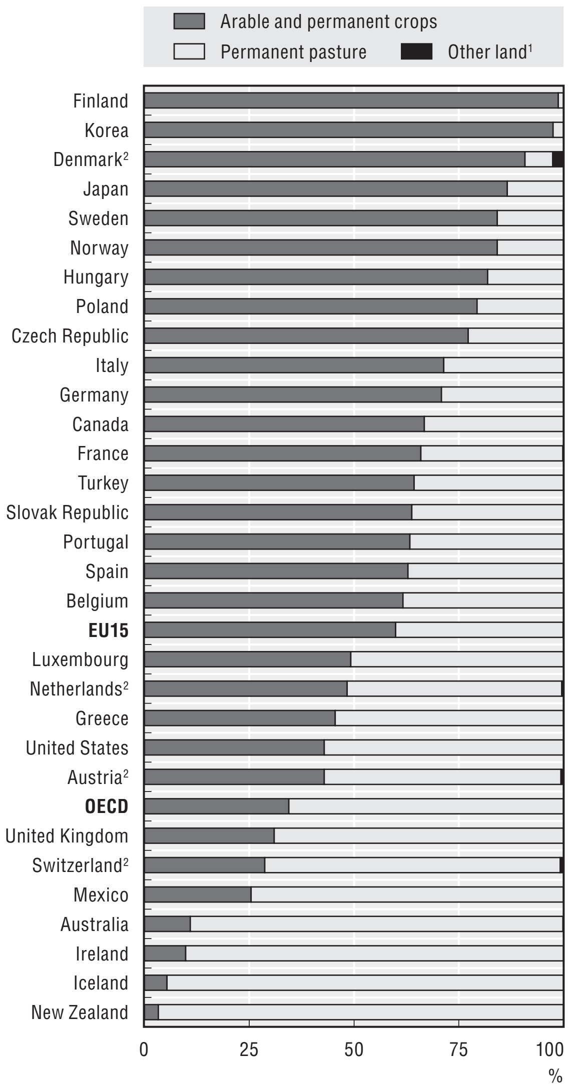
StatLink http://dx.doi.org/10.1787/288102440624

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

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

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

Percentage share in agricultural land, average 2002-04



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

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

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

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

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

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

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

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

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

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

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

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

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

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

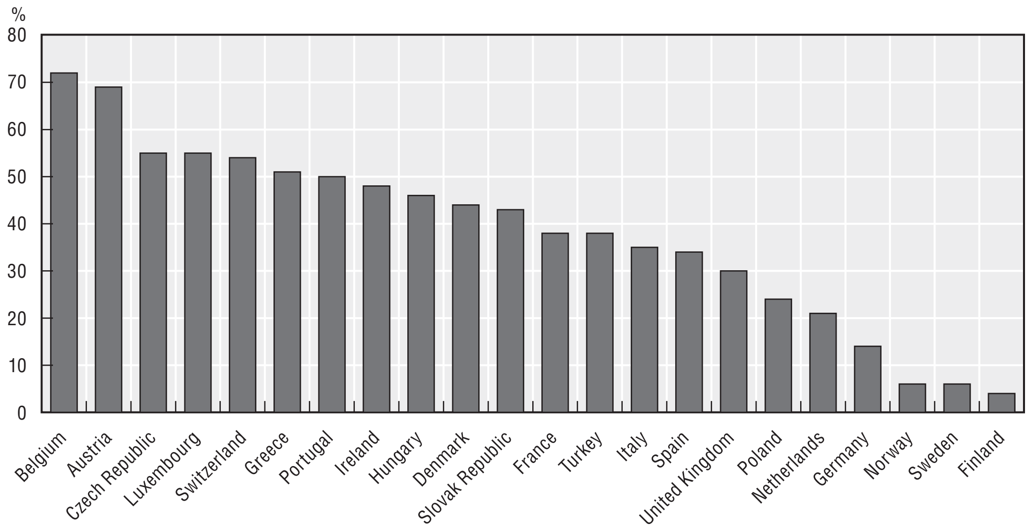
Source: OECD Agri-environmental Indicators Questionnaire, unpublished; FAOSTAT (2006); national data for Norway, Portugal and Spain.

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

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

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

Late 1990s



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

Source: BirdLife International (2004).

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1.9. FARM MANAGEMENT

KEY TRENDS

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

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

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

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

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

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

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

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Indicator definitions:

Nutrient management

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

Pest management

- Arable and permanent crop area under integrated pest management.

Soil management

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

Water management

- Irrigated land area using different irrigation technology systems.

Biodiversity management

- Agricultural land area under biodiversity management plans.

Organic management

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

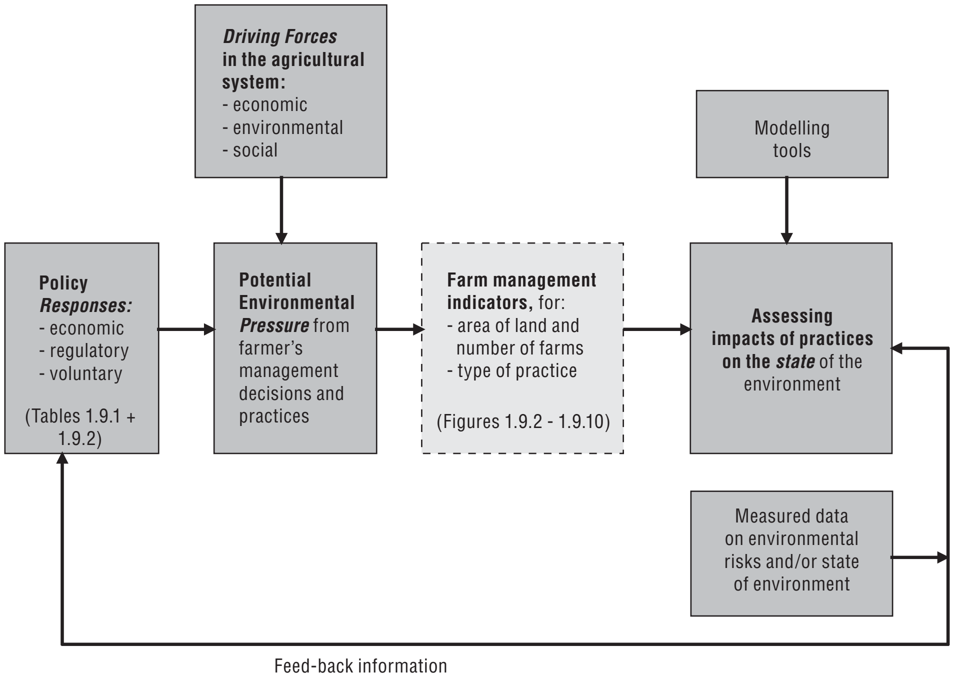
Concepts and interpretation

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

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

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

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



StatLink http://dx.doi.org/10.1787/288168718073

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

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

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

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

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

Recent trends

1.9.1. Overview of environmental farm management

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

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

1.9.2. Nutrient management

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

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

Late 1990s-early 2000s

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

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

Late 1990s-early 2000s

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

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

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

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

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

Late 1990s-early 2000s

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

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

Late 1990s-early 2000s

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

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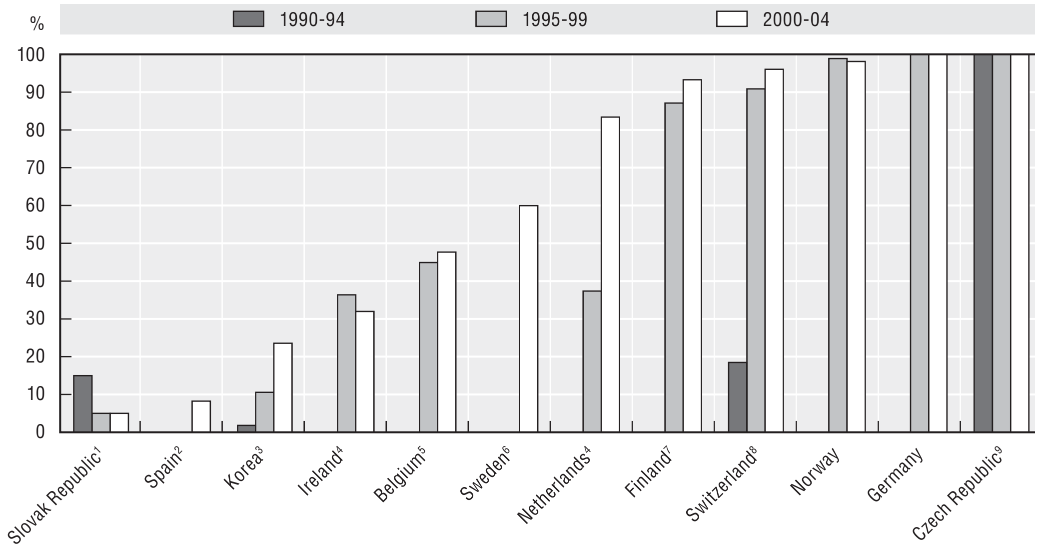
. .: Not available.

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

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

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

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



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

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

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

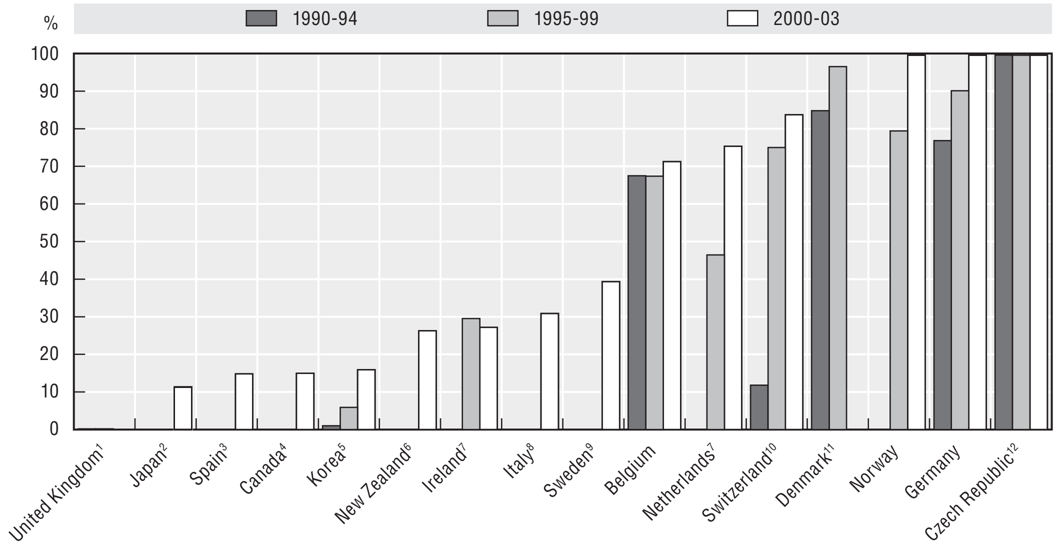
Source: OECD Agri-environmental Indicators Questionnaire, unpublished; national data sources.

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

1.9.3. Pest management

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

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



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

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

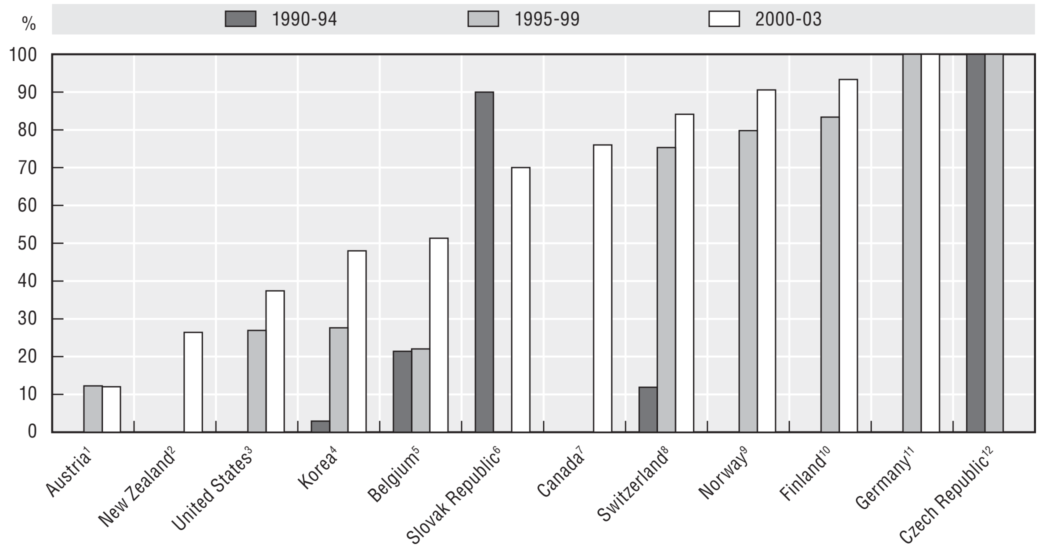
Source: OECD Agri-environmental Indicators Questionnaire, unpublished; OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; national data sources.

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

1.9.4. Soil management

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

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



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

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

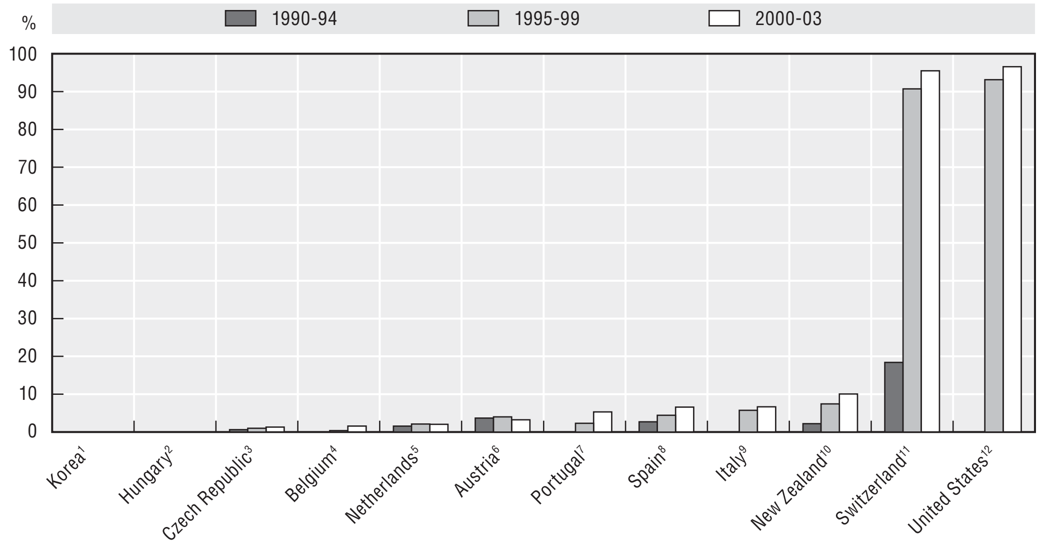
1. Soil tests cover phosphorus and potassium, tests are conducted every 4-5 years.
2. Nutrients covered by the management plan: nitrogen, phosphorus, potassium sulphur, magnesium, and other nutrients. Tests are conducted every 2-3 years; number of farms are estimated by the country.
3. Represents survey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

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

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

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

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



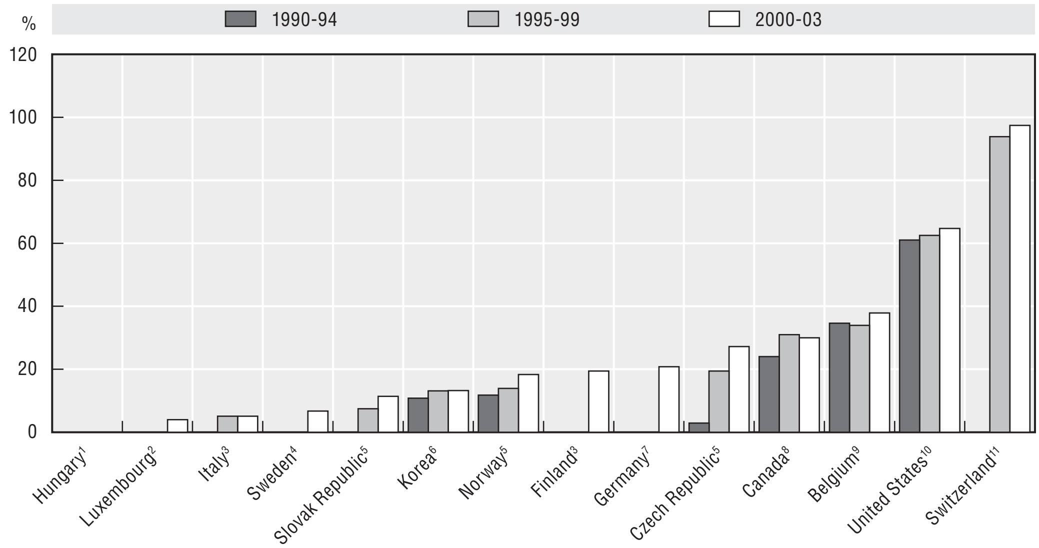
StatLink http://dx.doi.org/10.1787/288258134111

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

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

(Figures 1.9.6 and 1.9.7). In other countries, such as the **Czech** and **Slovak Republics**, the relatively low uptake of soil management practices may be aggravating soil erosion risks (Section 1.5). The poor uptake of soil conservation practices where soil erosion remains an important agri-environmental issue is also reported for **Hungary, Italy, Korea, Slovak Republic** and **Turkey** (Section 1.5 and Chapter 3).

Figure 1.9.6. **Share of arable crop area under soil conservation practices**



StatLink http://dx.doi.org/10.1787/288265066700

1. Value for 2000-03 is 0.1%, other years not available, includes total agricultural land and share of total agricultural land.
2. National data. Value for 2000-03 is 4%.
3. Includes total agricultural land and share of total agricultural land.
4. Data include arable crops (*e.g.* catchcrops, postponed autumn tillage and protection zones).
5. Data include only arable crops.
6. Data include permanent crops and pasture and share of permanent crops and pasture.
7. Data include only arable crops, data refer to 2003/04.
8. Share of cropland area in conservation tillage practices (%).
9. Data includes arable crops (*e.g.* winter wheat and barley for all years and green cover in winter for 1995 and 2000) for Flanders; the 1990-94 value is the sum of 1990 data for Flanders and 1994 data for Wallonia, the 1995-99 value is the sum of 1995 data for Flanders and 1999 data for Wallonia, the 2000-03 value is the sum of 2000 data for Flanders and 2003 data for Wallonia.
10. Data from USDA (2004), data for the period 1990-94 equal 1994; data represent cropland under crop residue management (*e.g.* no-till, conservation management) in US major agriculture productive areas.
11. Data for the period 1995-99 refer to year 1999. Data not available for the period 1990-94.

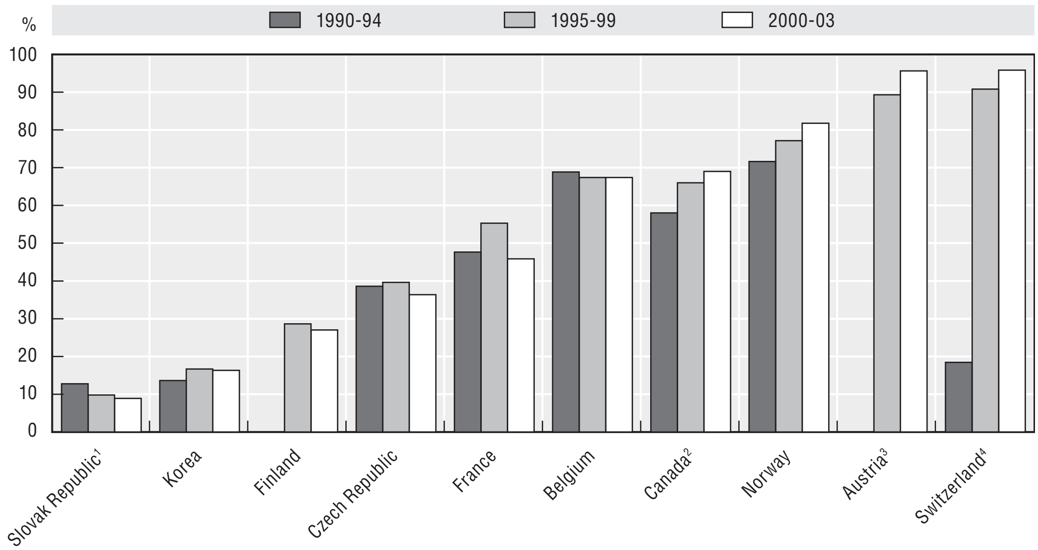
Source: USDA (2004); OECD Agri-environmental Indicators Questionnaire, unpublished.

1.9.5. Water management

For those OECD countries where irrigated agriculture is important, they are generally applying irrigation technologies that are poor in terms of water conservation (Figure 1.9.8). Crop irrigation in most countries involves flooding or high pressure raingun technologies, which use considerably greater quantities of water than the more efficient low pressure sprinklers and drip emitters. As in common with many other EFMPs water management practices are typically supported by government, but rarely obligatory or promoted voluntarily (Table 1.9.2).

The uptake of more efficient water management technologies (*i.e.* drip emitters) covers over 20% of the total irrigated area for only a few countries (**Czech Republic, Greece, Italy, Spain**). But for certain countries where irrigated agriculture contributes an important share in total agricultural output and value, and the pressure to conserve water resources is high in certain regions, the share of the more efficient drip emitter water application technology in irrigated areas is under 10% for **Australia, France, Turkey**, and the **United States**. However, for **Australia, France** and the **United States** there is more widespread use of low-pressure sprinklers (Figure 1.9.8).

Figure 1.9.7. **Share of total arable and permanent crop area under all-year vegetative cover**



StatLink http://dx.doi.org/10.1787/288274883027

1. Data for the period 1990-94, 1995-99 and 2000-03 refer to the year 1992 (12.8%), 1997 (9.8%) and 2002 (8.9%).
2. The percentages show the share of Cropland in Different Soil Cover Classes (%).The percentages shown include the following soil cover classes: very high (≥ 325 days coverage), high (300-324 days coverage) and moderate (275-299 days coverage).
3. Data for the period 1995-99 refer to the year 1999, and for 2000-03 refer to the year 2003.
4. Data for the period 1990-94, 1995-99 refer to year 1993 and 1999.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished; Lefebvre *et al.* (2005); national data sources.

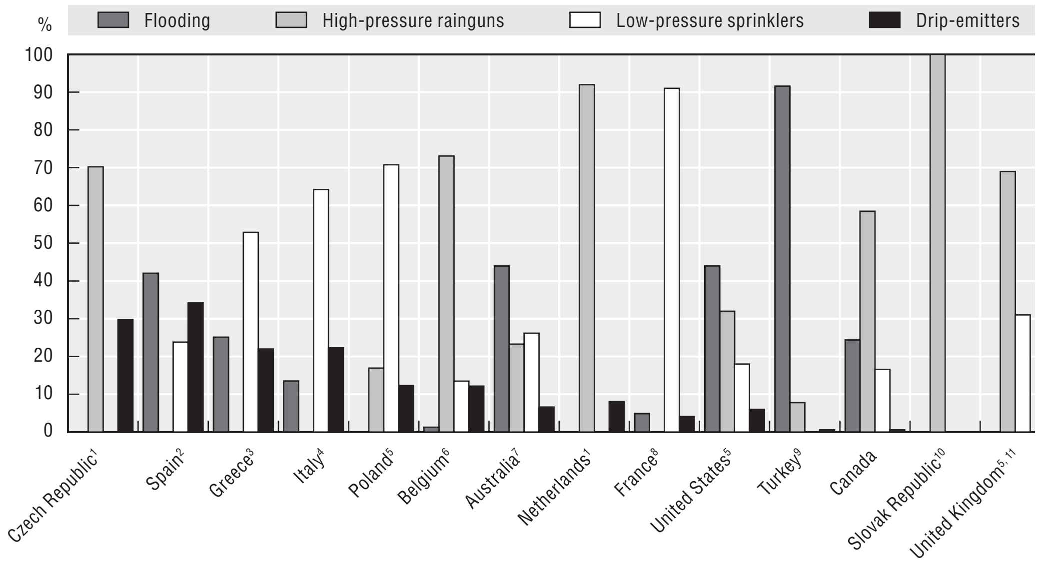
1.9.6. Biodiversity management

The share of agricultural land under biodiversity management plans (BMPs) is low for most OECD countries, except for **Austria, Ireland, Sweden** and **Switzerland** (Figure 1.9.9), although this conclusion should be treated with caution. Most countries are just beginning, or are in the process, of implementing biodiversity management plans in agriculture as part of their broader biodiversity action plans developed under the national implementation of the *Convention of Biological Diversity* (Section 1.8). In addition, many countries are only just starting to monitor the uptake by farmers of biodiversity management plans (about a third of OECD countries in 2003), which in many cases are supported or enforced by governments and regularly audited (Table 1.9.2).

Information on the characteristics of BMPs is currently lacking, but in some cases they cover, for example, conservation of endangered species (Section 1.8) and practices aimed at establishing and managing field margins and riparian buffers. As biodiversity and landscape management practices can be closely linked, it can be difficult to separate the two in a number of countries, such as in many European OECD countries.

Figure 1.9.8. **Share of irrigated land area using different irrigation technology systems**

2000-03



StatLink http://dx.doi.org/10.1787/288280262782

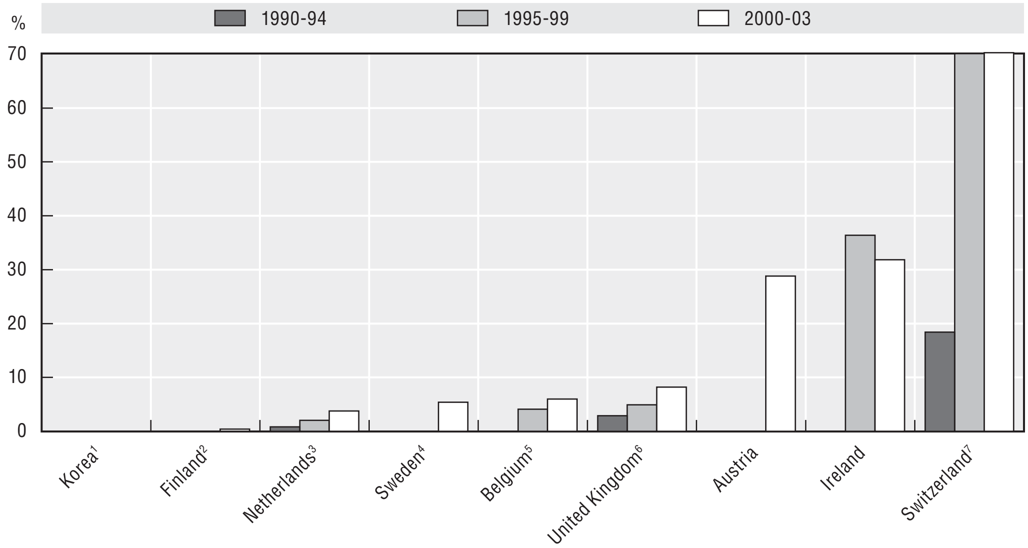
1. Data for 2003.
2. The data are for 2002-03 and represent the area for flooding, sprinklers and drip emitters that are irrigable but not necessarily irrigated.
3. Data for 1999, which show different irrigation technologies' share of total irrigation water use.
4. Data for 2000.
5. National data.
6. Data for Flanders refer to 2002. Flooding data include Wallonia and Flanders data, but for Flanders only ornamental plant cultivation in greenhouses are included; high-pressure raingun data refer only to Flanders; data for low-pressure sprinklers and drip emitters are the sum of Flanders and Wallonia data.
7. Data are taken from the Australian Bureau of Statistics (2005), Irrigation Methods 2002-03; flooding refers to surface, low-pressure sprinklers refer to microspray, drip-emitters refers to drip or trickle, and high-pressure rainguns refers to portable irrigators, hose irrigators, large mobile machines and solid set.
8. Values are an average of data for 2000 and 2003.
9. Data for 2000, value for high-pressure rainguns include area irrigated by low-pressure sprinklers.
10. Data for 2000-03.
11. Data for England.

Source: Australian Bureau of Statistics (2005); OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France, OECD Agri-environmental Indicators Questionnaire, unpublished.

1.9.7. Organic management

The OECD area under certified organic farming has increased substantially, especially since 1993-95, but accounted for less than 2% of total OECD farmland by 2002-04 (Figure 1.9.10). However, there is considerable variation in the importance of organic farming across countries, with the share in the total agricultural area higher in OECD European countries (*e.g.* around 6% or higher in **Austria, Denmark, Finland, Italy** and **Switzerland**) but much lower in non-European OECD countries (*e.g.* under 1% in **Canada, Japan, Korea, Mexico, New Zealand** and the **United States**), except notably **Australia** where it is over 2%, and in **Greece, Iceland, Ireland, Poland** and **Turkey** where it is also very low.

Figure 1.9.9. **Share of agricultural land area under biodiversity management plans**



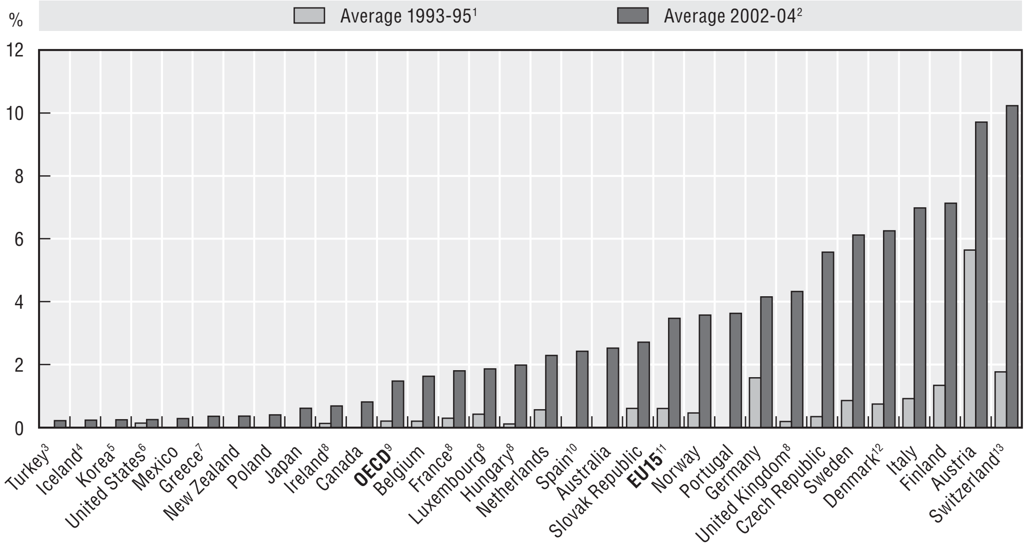
StatLink http://dx.doi.org/10.1787/288303510537

1. Value is 0.02% for 2000-03, data for other years are not available.
2. Value for 2000-03 is 0.42%, other years are not available.
3. Value for 1990-94 is 0.8%, data for 2003 are an estimate by the Netherlands.
4. Data include only pasture and share of pasture area.
5. Data represent Flanders and Wallonia; value of 2001 is the sum of Flanders (2001) and Wallonia (2003).
6. Includes area under the "Wildlife Enhancement Scheme" and "Agri-environment Schemes".
7. Data for the period 1990-94 and 1995-99 refer to the year 1993 and 1999.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

The importance of organic farming varies not only between countries, but also between different commodities within countries. In **France**, for example, pasture is largely under organic systems compared to arable land, while amongst arable crops the share of fruit and vegetables produced organically tends to be higher than for cereals, sugar and oilseed crops. For livestock products growth in organic production has been most rapid for milk and poultry meat. In terms of the share of organic foods in total retail food sales the share varies across countries, but it is also small, for example, around 2% (2003) in the **United States**. Milk, fruit and vegetables account for the major part of organic production and retail sales in both the **United States** and **EU15** (EEA, 2005; OECD, 2003b; USDA, 2005).

Figure 1.9.10. **Share of agricultural land area under certified organic farm management**



StatLink http://dx.doi.org/10.1787/288310605203

1. Data for 1993-95 are unavailable for Australia, Canada, Japan, Mexico, New Zealand, Poland and Portugal.
2. Data for 2002-04 are taken from IFOAM (2007).
3. Value for 1993-95 is 0.01. Data for 1994 are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France.
4. Value for 1993-95 is 0.004. Data for 1993-95 are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3.
5. Value for 1993-95 is 0.001. Data for 1995 are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3.
6. Value for 1993-95 equals data for 1997 (0.14%) and value for 2003 equals data 2001 (0.25%). Data from national source.
7. Value for 1993-95 is 0.02; data are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3.
8. Data for 1993-95 are taken from IFOAM, other data are taken from OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3.
9. Australia, Canada, Japan, Mexico, New Zealand, Poland and Portugal are not included in the OECD for 1993-95.
10. Data for the period 1993-95 refer to year 1993, the value is 0%.
11. Portugal is not included in the EU15 for 1993-95.
12. Data for 1994 equal 1993-95 average.
13. Data for the period 1993-95 refer to the year 1993.

Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; OECD Agri-environmental Indicators Questionnaire, unpublished; IFOAM (2007).

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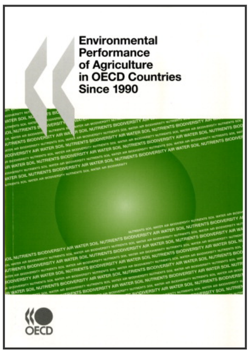
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