Measuring the Environmental Impacts of the Common Agricultural Policy: Challenges, Recent Trends and Outlook, and Future Directions

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Abstract: The development of policy relevant indicators is important if future environment oriented expenditure within agricultural policy is to achieve value for money. Appropriate agri-environmental indicators can be useful in improving transparency, accountability and ensuring the success of monitoring, control and evaluation. Against this background the paper sets out (Section I) to examine the policy challenges in Europe that need to be addressed in developing policy relevant indicators. It then (Section II) describes recent trends and the future outlook to 2020 of the environmental impacts of the Common Agricultural Policy, including agriculture's role in protecting the stock of natural resources and landscapes; reducing environmental pollution from agriculture; and improving agri-environmental management and resource use efficiency. The paper concludes (Section III) by examining the future directions for indicators as a tool for policy purposes.

I. Challenges: The Agri-Environmental Policy Context In Europe

Agriculture plays only a small part in the economies of European Union (EU) member countries, accounting for about 2% of GDP and 5% of EU employment. But in terms of its impact on the environment and natural resources, agriculture's role is more significant accounting for 45% of EU total land use and over 30% of total water use.

In view of the growing public concern with environmental quality and natural resource use, EU member countries, as with many other OECD countries, have substantially increased their public expenditure on agri-environmental programmes over the 1990s, in part, to offset the negative impacts from the continuation of production enhancing policies (Figure 1). The greater policy focus on agri-environmental issues can be expected to intensify over the coming decade as a consequence of:

- reforming the Common Agricultural Policy (CAP);
- developing agri-environmental measures, in particular, under EU Regulation 2078/92; and
- strengthening environmental policies domestically, especially under the EU's 6th Environment Action Programme (EAP) that sets out the main priorities and objectives for environment policy from 2001 to 2010, and multilaterally, for example, the Convention on Biological Diversity.

The 1992 CAP reforms gave higher priority to the environment within agricultural policy, and this trend was continued under the recent "Agenda 2000" programme. These reforms are beginning to improve the domestic and international allocation of resources, and reverse the harmful environmental impacts associated with commodity and input specific policy measures, by reducing incentives to use polluting chemical inputs and to farm environmentally sensitive land.

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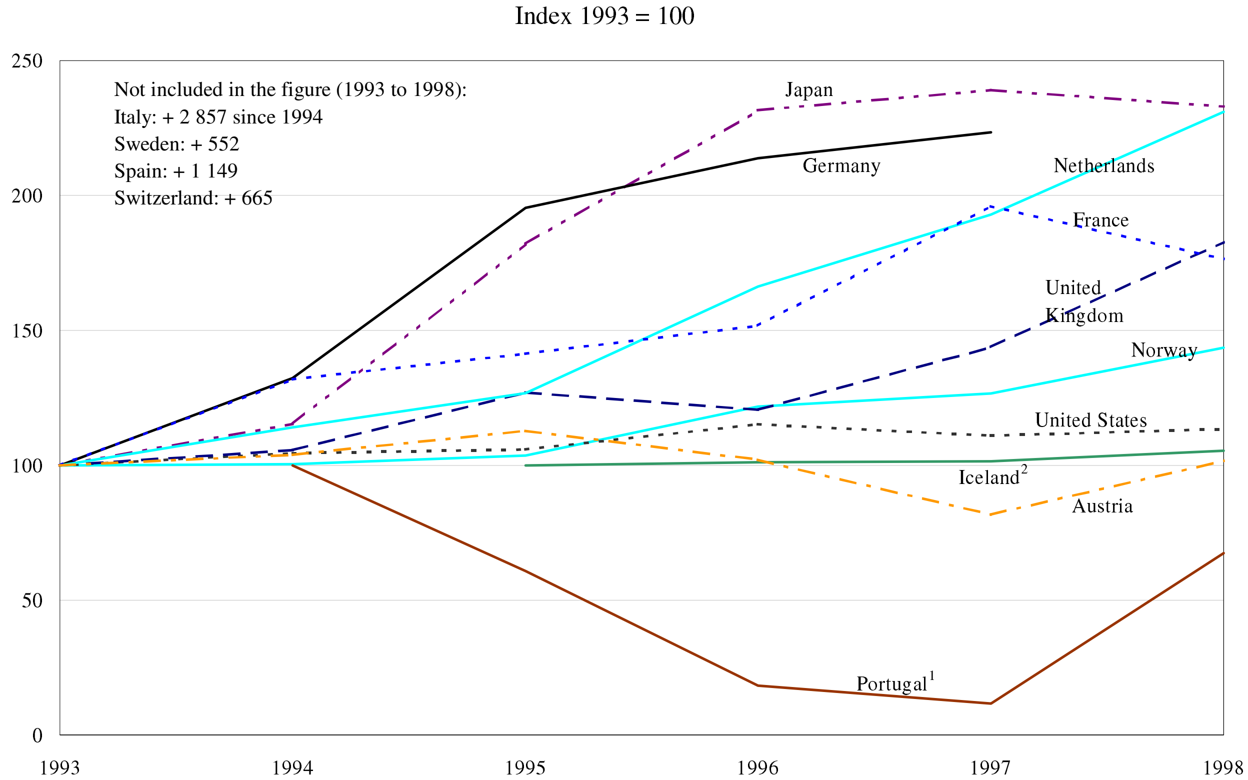
Figure 1. **Public expenditure on agri-environmental goods, services and conservation: 1993 to 1998**



Notes:

1. 1994 = 100.
2. 1995 = 100.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 69, Publications Service, Paris, France.

A report by the European Communities Court of Auditors (2000) noted that "the intensification of agricultural production, encouraged by high support under the Common Agricultural Policy and partly by agronomic trends, has created environmental problems which give cause for concern [para 1]… the Community may have succeeded in "greening" its CAP but not necessarily agriculture. The expected environmental benefits of the changes made by the Reform of 1992 ….are not yet realised to a significant extent " [para. 91].

Even so, the support to EU agriculture has declined over the pass 15 years, as measured by the OECD Producer Support Estimate (PSE) (Figure 2). Also over this period there has been a shift in the composition of support from market price support and payments based on output, toward area and headage payments falling from 91% of the PSE in 1986-88 to 66% in 1998-2000. This development has the potential to reduce the effects of support on production and trade, (OECD, 2001a).

As part of the CAP reform process the ***EU has also introduced various agri-environmental measures,*** the "accompanying measures", to encourage the adoption of environmentally friendly farming practices (Regulation No. 2078/92) and the afforestation of agricultural land (Regulation No. 2080/92). Consequently EU agri-environmental expenditure has increased substantially, but nevertheless, remains less that 5% of total CAP budgetary expenditure (Figure 1). While the nature of implementing Regulation No. 2078/92 has varied across countries, they have mainly focused on altering inappropriate farm management practices that are incompatible with achieving environmental objectives, some of which were encouraged by high price support levels,. Agri-environmental measures have also included the provision of payments if certain practices are adopted, such as conversion payments for changing to organic farming.

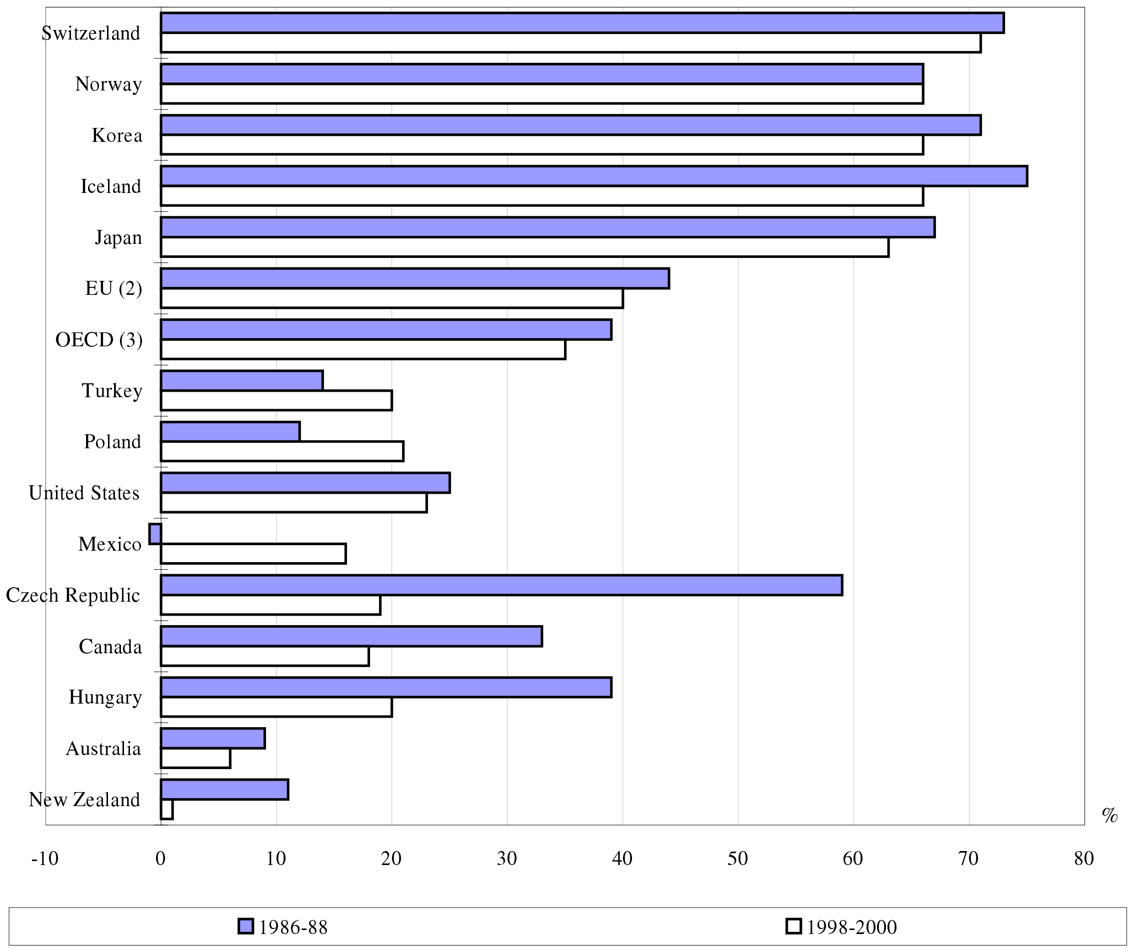
The EC Court of Auditors (2000, para. 93) in their assessment of the EU agri-environmental (AE) measures observed that they "have had some beneficial environmental impact, particularly in providing incentives to farmers to maintain their extensive farm practices, and avoiding the abandonment of farm lands or their conversion to intensive farming. But the AE measures have had very little effect in converting intensive practices to extensive farming. One of the main reasons for this unsatisfactory performance is the Commission's and Member States'weaknesses in resource targeting, programme design, approval, and evaluation."

Future developments in ***domestic environmental measures and multilateral environmental agreements*** are also expected to have an increasing influence on the EU's farming sector for three reasons:

1. Progress in reducing ***environmental pollution*** from industrial and household waste is shifting the focus to the agricultural sector, as its share in total emissions for certain pollutants, especially nitrates and phosphates, has risen. As a result there is growing pressure that the tax and regulatory measures that are commonly used to control pollution from industry and households should also be extended to cover the agricultural sector which has often been exempt from such measures, that is to say the application of the polluter-pays-principle. The EU's 6th EAP highlights the need to further deepen the integration of environmental concerns in to other policies, including agriculture.

2. Given that agriculture is the major user of land and water in most EU countries, environmental policies that address ***resource depletion issues, and the conservation of biodiversity, habitats and landscapes***, inevitably involve agriculture. In the case of water resources, for example, in some regions within EU countries competition for water resources is growing between different users and to maintain aquatic ecosystems. As a response to these pressures the EU Water Framework Directive provides an integrated approach to water reform, covering the principal users, including agriculture, and addressing issues related to water pricing and environmental impacts of water use.

Figure 2. **Percentage Producer Support Estimate[1]: 1986-88 to 1998-2000**



Notes:

1. The Producer Support Estimate (PSE) is an indicator of the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at farm gate level, arising from policy measures which support agriculture, regardless of their nature, objectives or impacts on farm production or income. The percentage PSE measures the share of support to producers in total gross farm receipts.
2. EU-12 for 1986-88; EU-15 for 1998-2000. PSEs are not caculated by the OECD Secretariat for individual EU Member states.
3. OECD includes the most recent Member countries for both periods (date of OECD membership in brackets): Czech Republic (1995), Hungary (1996), Korea (1996), Mexico (1994), and Poland (1996).

Source: OECD (2001), Agricultural Policies in OECD Countries - Monitoring and Evaluation 2001, Publications Service, Paris, France.

3. There are an increasing number of ***multilateral environmental agreements*** which have implications for agriculture, some operating at regional scales such as the Convention for the Prevention of Marine Environment of the North-East Atlantic (OSPAR Convention) and the European Landscape Convention, and others operating at the global scale, for example the UN Framework Convention on Climate Change, the Convention on Biological Diversity, and the Montreal Protocol on Substances that Deplete the Ozone Layer. The commitments established under these agreements are already having an impact on agriculture in EU countries, for example, the control of nutrient and pesticide run-off into international waters; the gradual phase out of the use of the methyl bromide pesticide as a ozone depleting substance; and the implementation of national biodiversity action plans, which include biodiversity conservation in agriculture.[2]

II. Measuring the Environmental Impacts of The Common Agricultural Policy: Recent Trends and Future Outlook to 2020

Agriculture's impact on the environment can be described in terms of a sequence of processes. The quantity of agricultural production is affected by the financial resources available to agriculture (both returns from the market and government support), the incentives and disincentives facing farming, and the kinds of management practices and technologies adopted by farmers.

These practices and technologies impact on the productivity of the natural resources (e.g. soil) and purchased inputs (e.g. fertilisers) used by farmers. Depending on the management and productivity of agriculture's use of resources and inputs this will affect the rate of depletion and degradation of soils and water; the flows of harmful emissions (e.g. nutrients) into soils, water, air and the atmosphere; and the quantity and quality of plant and animal resources (i.e. biodiversity and habitats) and landscape features.

This section examines these how these agri-environmental impacts have been evolving across the EU since the mid-1980s and how they may develop up to 2020,[3] in terms of agriculture's role in:

1. Protecting the stock of natural resources and landscapes impacted by agriculture.
2. Reducing environmental pollution from agriculture.
3. Improving agri-environmental management practices and resource use efficiency.

1. Protecting the Stock of Natural Resources and Landscapes Impacted by Agriculture

Agriculture plays a critical role in the protection (or depletion) of the stock of natural resources used for production, notably soil and water resources, because for most EU countries agriculture accounts for the major share in the use of these resources. Farming activities also impact on the quality and quantity of natural plant and animal resources (i.e. biodiversity and habitats) and landscapes, both on and off-farm.

i. Land use and Soil quality

At present agriculture accounts for 45% of total ***EU land use***, ranging from under 10% in Finland and Sweden, to over 70% in Greece and the United Kingdom (OECD, 2001b). By 2020 about 5% of current agricultural land is expected to be converted to other uses, mainly the reversion of marginal farm land to commercial forests or 'natural' habitats, such as reclaimed wetlands (OECD, 2001d).

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[2] It should be noted that many of the multilateral environmental agreements mentioned here have been signed by countries, but many fewer countries have ratified the agreements.

[3] This section draws, in particular, from the OECD work on agri-environmental indicators, especially OECD (2001b) and agricultural projections to 2020 in OECD (2001c; and 2001d).

Further urban encroachment is also expected to lead to the loss of some highly productive agricultural land, a development which is in general irreversible. However, the conversion of agricultural land to other uses may vary across the EU. For example, of the agricultural land converted to other uses in Austria over 60% changed to use for forestry, while in Spain and the UK only 30% changed to forestry, during the period from the mid–1980s to the mid–1990s (OECD, 2001b).

While there are a large number of threats that impair ***soil quality*** across the EU, including changes in land use and cover, the main influences originate from altering farm management practices. Poor soil conservation practices on agricultural land can increase rates of ***water and wind erosion*** above those levels that occur naturally. Although the area of agricultural land at high/severe risk to water erosion is not extensive across EU countries (i.e. above 22 tonnes/hectare/year), for some countries more than 10% of agricultural land fall within this risk class, notably Italy, Portugal and Spain (Figure 3).

There is incomplete information to assess whether there have been changes in soil erosion rates across the EU over the past 15 years. But it is likely that improvements in lowering erosion rates have occurred as a result of increased land set-aside, the adoption of conservation tillage practices, and less intensive crop production, partly as a result of the switch to area payments in the EU (OECD, 2001b).

As regards ***other threats to soil quality in the EU***, such as loss in soil fertility, soil compaction, salinisation and acidification of soils, and pollution from farm chemicals and heavy metals, as with soil erosion, information is incomplete. Little is also known of the economic costs associated with soil degradation or the monetary benefits of different soil conservation strategies. Against this background the EU's 6th EAP has concluded that "little attention has so far been given to soils in terms of data collection and research…..Given the complex nature of the pressures weighing on soils and the need to build a soil policy on a sound basis of data and assessment, a thematic strategy for soil protection is proposed. The EU research programmes should support this work" (Commission of the EC, 2001a, pp.35).

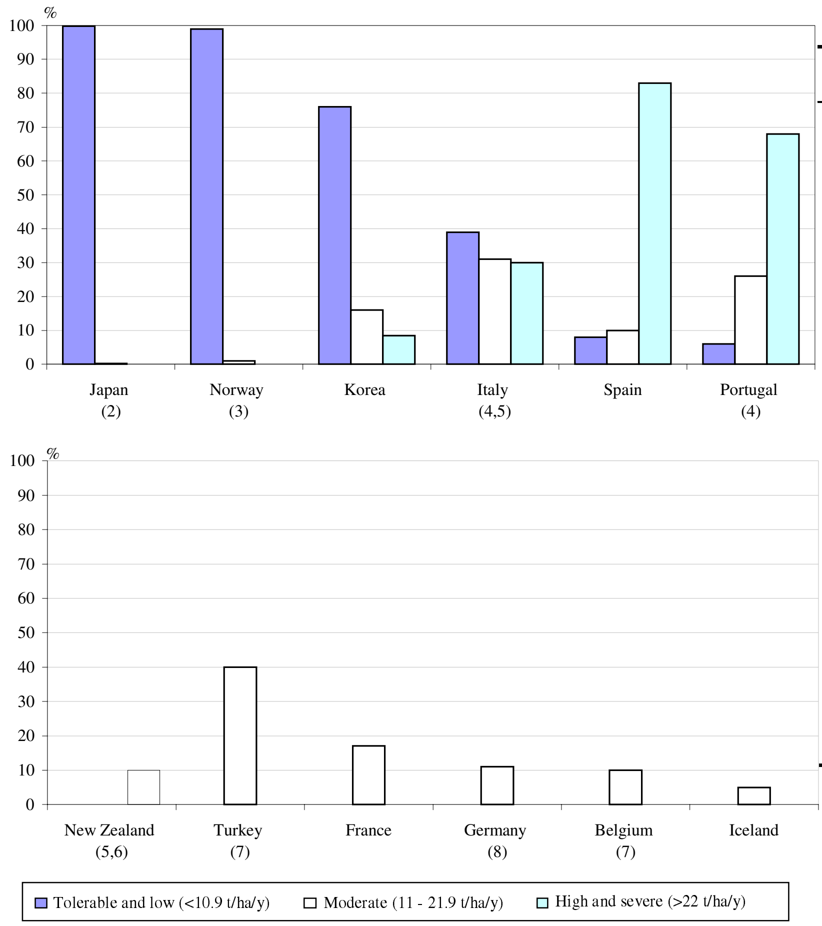
ii. Water resources

Large numbers of the world's population are projected to experience severe pressure on the ***availability of water*** by 2025, the main consequence of which will be on the food supplies of the poor. Even with greatly improved irrigation water use efficiency it is anticipated that one third of the world's population will remain short of water by 2025 (Merrey and Perry, 1999; and Seckler, *et al*, 1998) Agriculture currently accounts for over 30% of total EU water utilisation, and for over 55% in four EU countries (OECD, 2001b; FAO, 2000, pp.109-116). The EU irrigated area increased by over 22% from 1980-82 to 1994-96, although over this period total EU agricultural water use rose by only 10% (Figure 4).

Given the modest growth in EU crop production projected up to 2020, compared to the higher growth rates in the 1990s (Figure 5), the total ***irrigated area*** is unlikely to show the same rate of expansion. But for some southern regions of the EU, where irrigated agriculture is more important, then the irrigated area could expand more rapidly. Trends in future EU agricultural water use will be mainly affected by the market prices for irrigated crops and related changes in the area of irrigated crops, the level of support provided to farmers for water use, and improvements in water use efficiency (see section III below).

For most EU Member states, in common with other OECD countries, ***water charges*** for farmers are substantially below that paid by other users due to government support for irrigation infrastructure and water delivery costs (Figure 6). Under the newly adopted (September 2000) European Union Water Framework Directive, EU farmers will be required to comply with water pricing policies that meet environmental objectives. Evidence in some EU countries would suggest that farmers are close or already paying the full recovery cost for water, while in some other Member states this is not the case (Figure 6).

Figure 3. **Share of agricultural land area affected by water erosion by area assessed: 1990s[1]**



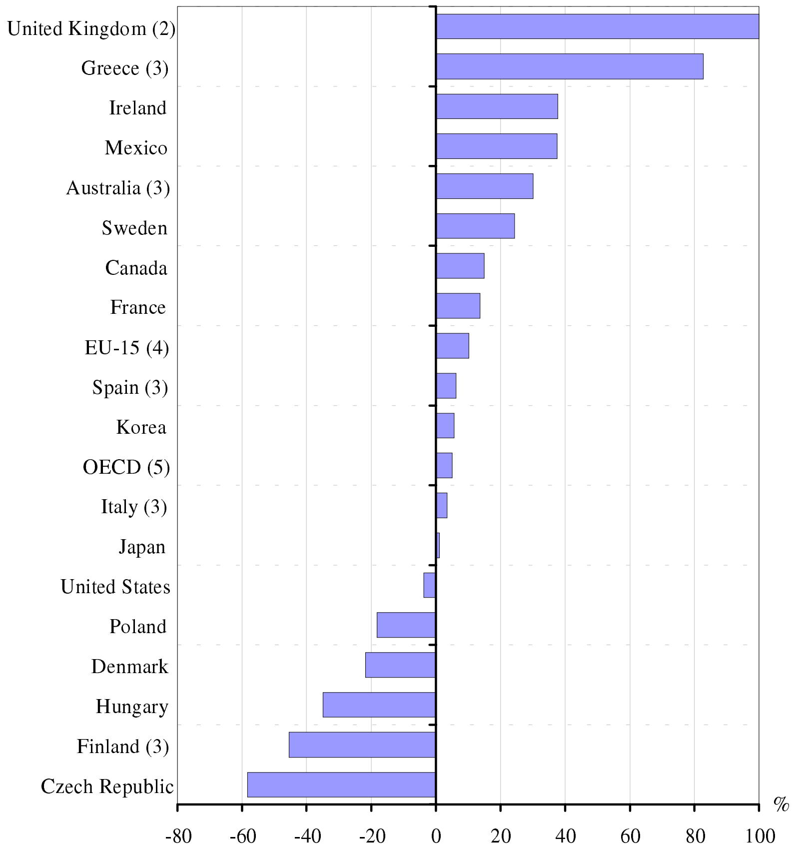
	% of agricultural area assessed	Period assessed
Japan	100	1987
Norway	100	1997
Korea	97	1985-97
Italy	100	early 1990s
Spain	87	1980
Portugal	100	early 1990s
New Zealand	100	mid/late 1970s
Turkey	100	early 1990s
France	100	mid-1990s
Germany	100	1996
Belgium	100	mid-1990s
Iceland	100	late 1990s

Notes:
1. Some caution is required when making comparisons between graphs due to differences in agricultural land areas assessed, and the time period cove It should be noted that the classification of different soil erosion categories used in this figure is not necessarily that used by countries as categories were changed to aid comparison. Data for the Netherlands are not included as the area assessed is only 1% of total agricultural land.
2. Tolerable and low: 99.7%, Moderate: 0.3%, High and severe: 0.01%
3. Tolerable and low: 99%, Moderate: 1%, High and severe: 0%
4. Values in figure apply to potential risk.
5. Water and wind erosion combined.
6. Data exist only for high and severe erosion and relate to surface erosion, mass movement erosion, and fluvial erosion .
7. Values exist only for areas "susceptible" to erosion.
8. Data represent East Germany.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 203, Publications Service, Paris, France.

Figure 4. **Total agricultural water use[1]: early 1980s to mid / late 1990s**

Change in total agricultural water use



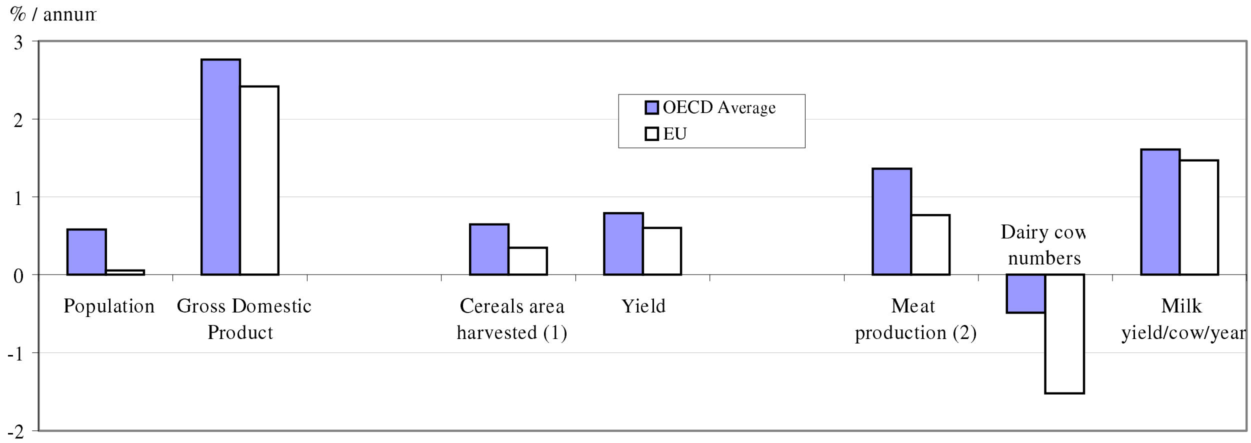
Agriculture water use
million m^3

	early 1980s	mid / late 1990s
United Kingdom	82	184
Greece	4 158	7 600
Ireland	130	179
Mexico	45 953	63 200
Australia	8 100	10 539
Sweden	140	174
Canada	3 472	3 991
France	4 372	4 971
EU-15	67 515	74 389
Spain	26 220	27 863
Korea	14 100	14 900
OECD	402 011	422 377
Italy	31 920	33 040
Japan	58 000	58 600
United States	202 800	195 200
Poland	1 323	1 083
Denmark	460	360
Hungary	700	456
Finland	33	18
Czech Republic	48	20

Notes:
1. 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.
2. England and Wales only. Percentage equals 124%.
3. Data for irrigation water use were used as data for agricultural water use are not available.
4. Austria, Belgium, Germany, Luxembourg, the Netherlands, and Portugal are excluded.
5. Austria, Belgium, Germany, Iceland, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Switzerland and Turkey are excluded.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 177, Publications Service, Paris, France

Figure 5. **OECD and EU Economic and Agricultural Projections, 1995 to 2020**

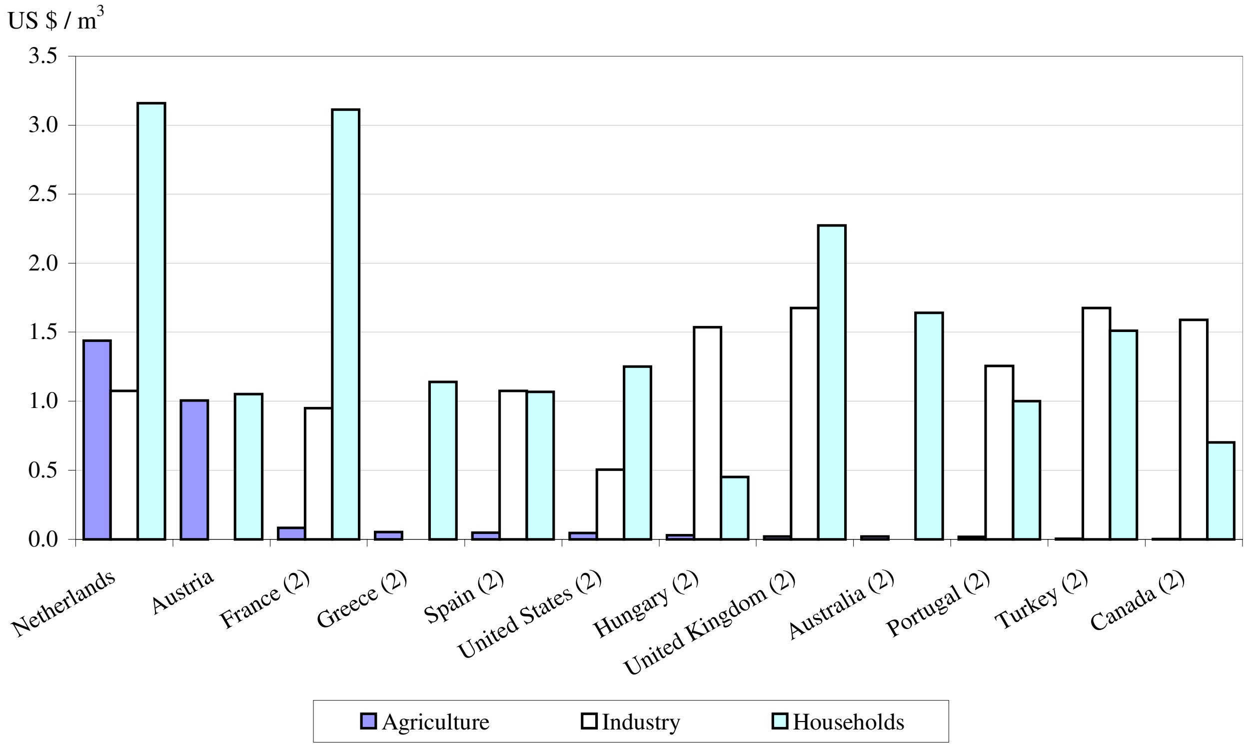


Notes:

1. Cereals include: rice, wheat and coarse grains.
2. Meat production includes : beef and veal, poultry, pigmeat and sheepmeat.

Source: OECD (2001), OECD Agricultural Outlook 2001-2006, Publications Service, Paris, France.

Figure 6. **Comparison of agricultural, industrial, and household water prices[1]: late 1990s**



Notes: Some caution is required in comparing agricultural water prices with other user prices because water supplied to agriculture is usually of a lower quality than that provided to households and, on occasion, industry; while the capital costs of water conveyance systems are generally lower for agriculture than for household or industry.

1. For agriculture, industry, and households, prices are the median values for the range of prices for each category.

2. Agricultural water prices are less than 0.1 US $/m^3.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 185, Publications Service, Paris, France.

A recent study by Baldock *et al*, 2000, assessing the environmental impacts of irrigation in the EU, noted that "agricultural water pricing does not follow a consistent pattern between Member States but the overall level of prices is relatively low. In the EU as a whole, especially where large, collective irrigation networks are managed by public bodies, the price of water to farmers rarely reflects its full resource and environmental cost…(p.ii)…Policy developments could include the adoption of water charging regimes which internalise external costs, policies to establish collective management structures, and more widespread use of metering and independent enforcement in relation to environmental protection." (p. vi)

iii. Biodiversity and habitats

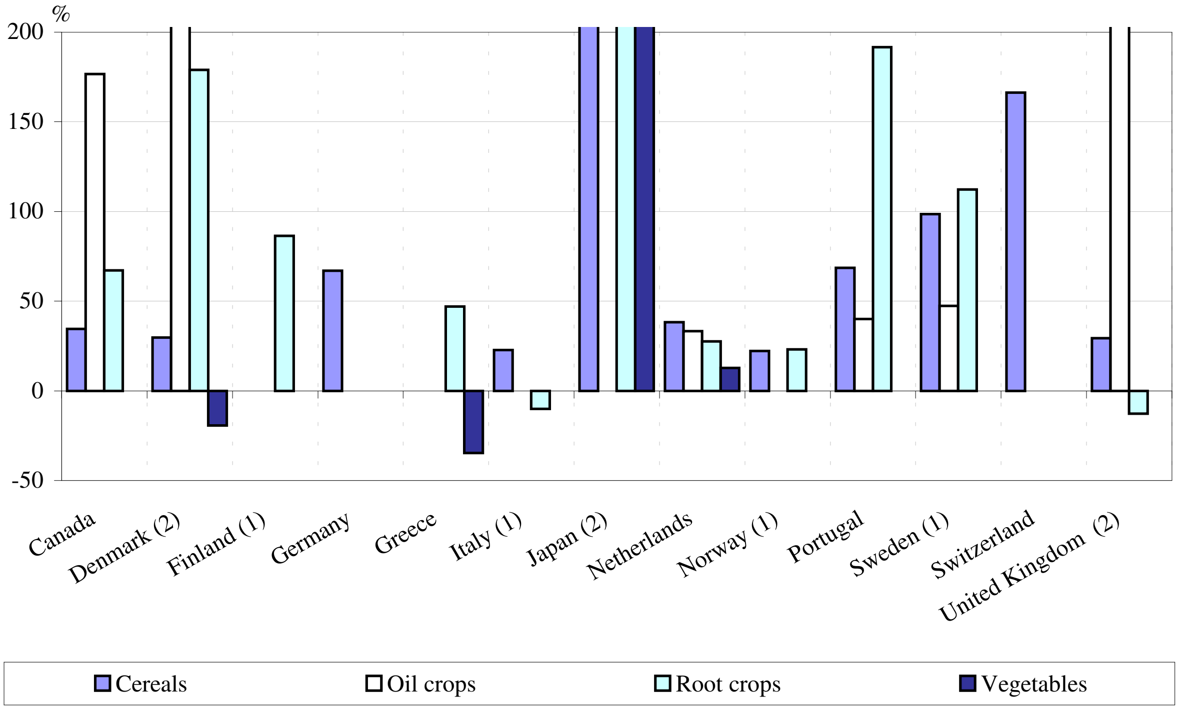
There is increasing public and policy focus on the relationship between ***agriculture, biodiversity and habitats*** (i.e. ecosystems), both internationally, for example under the Convention on Biological Diversity, and at the local and regional levels within countries, such as the EU's Biodiversity Action Plan for Agriculture (Commission of the European Communities, 2001b). The EU's 6th EAP (Commission of the European Communities, 2001a, p37) has commented that in addition to implementation of Action Plans "future work on preserving biodiversity needs to be strengthened with better knowledge. In particular, we need to know more about the state of biodiversity and the pressures and trends. …. With good data, more useful indicator sets can be developed to explain the trends and their causes to policy-makers and the wider public. Work is already underway with agriculture and environment indicators to define the indicators and corresponding data."

Concerning ***genetic diversity of agricultural crops and livestock***, recent trends reveal that agriculture in many EU countries is reducing the susceptibility to pest and disease risks by diversifying the crop varieties and livestock breeds used in production (Figures 7 and 8). Information on genetic erosion or loss is incomplete, but for some countries losses or endangerment of loss of genetic resources in agriculture and related wild relatives, has been significant over recent decades. Even so, collections in public and private genebanks continue to grow. But genetic modification in agriculture, especially genetically modified crops, poses potential risks to agricultural genetic diversity, in particular, by threatening landraces and adversely affecting other wild species. This technology, however, may offer the opportunity to raise agricultural productivity and, for example, reduce production risks by making available crop varieties that are drought and pest resistant.

For EU countries Regulation No.1467/94 provides a programme for the conservation, characterisation, collection and utilisation of genetic resources in agriculture, while in principle conservation of agricultural genetic resources can be supported through EU Regulation No. 2078/92 (European Commission, 1998, pp. 48-50). The latter EU regulation is applied to promote conservation of threatened farm animal species through provision of support for farmers who undertake to rear local livestock breeds in danger of extinction and to cultivate crops threatened by genetic erosion (European Commission, 1999, p.131).

The impact of agriculture on the quality and quantity of ***species and eco-system diversity***, is to a large extent determined by the expansion (or contraction) of the farmed land area, and the intensity of agricultural production in terms of input use and farming practices. A number of agro-ecosystems can serve to maintain wild species diversity, such as some pasture and grassland systems (Figure 9). The complex ecology of flora and fauna have adapted to and been influenced by farming activities in Europe over thousands of years. The result is that many species are dependent for their lifecycle on the continuation of farming practices, such as the Great Bustard which thrives in extensive mosaics of cereals, fallow and pasture in Portugal and Spain. Also over 70% of threatened vascular plant species in Sweden, for example, depend on open farmed landscapes (Commission of the EC, 1999a, pp.16-18).

Figure 7. **Number of plant varieties registered and certified for marketing: 1985 to 1998**

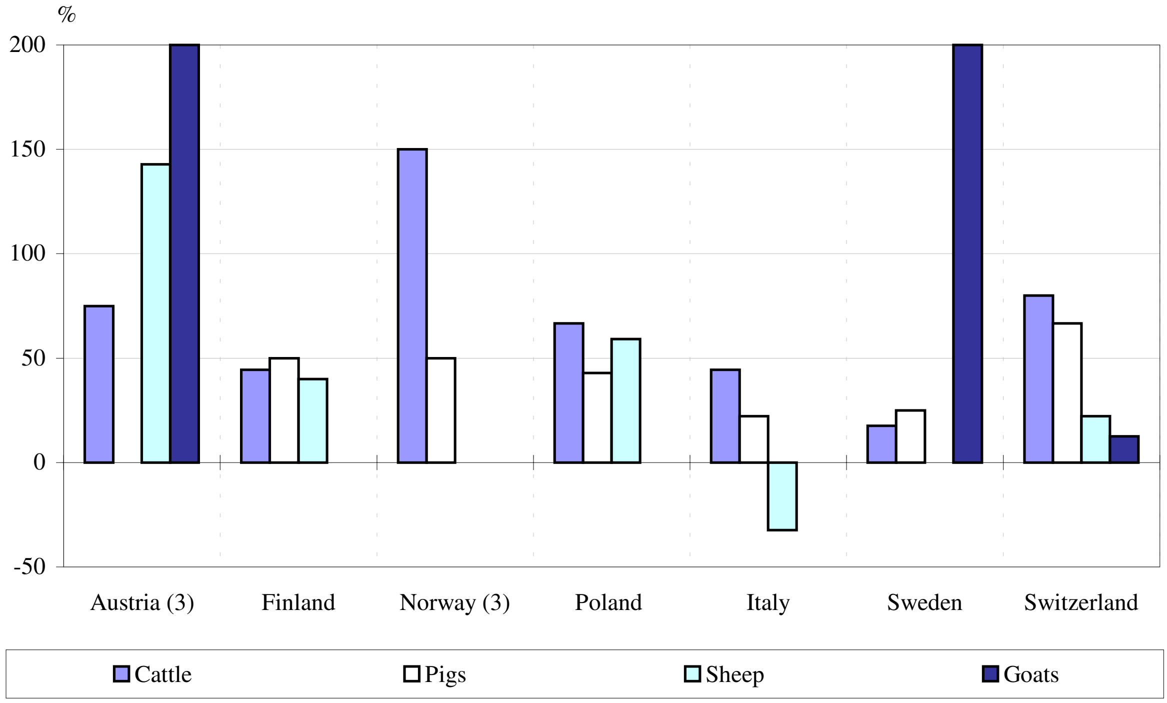


Notes: Data are not available for all crop categories and all countries.

1. Percentages are zero or close to zero per cent for Finland (cereals, oil crops, vegetables), Italy (oil crops), Norway (oil crops), Sweden (vegetables).
2. Percentages are greater than 200% for Denmark (oil crops), Japan (cereals, root crops, vegetables), United Kingdom (oil crops).

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 301, Publications Service, Paris, France.

Figure 8. **Number of livestock breeds[1] registered or certified for marketing[2]: 1985 to 1998**

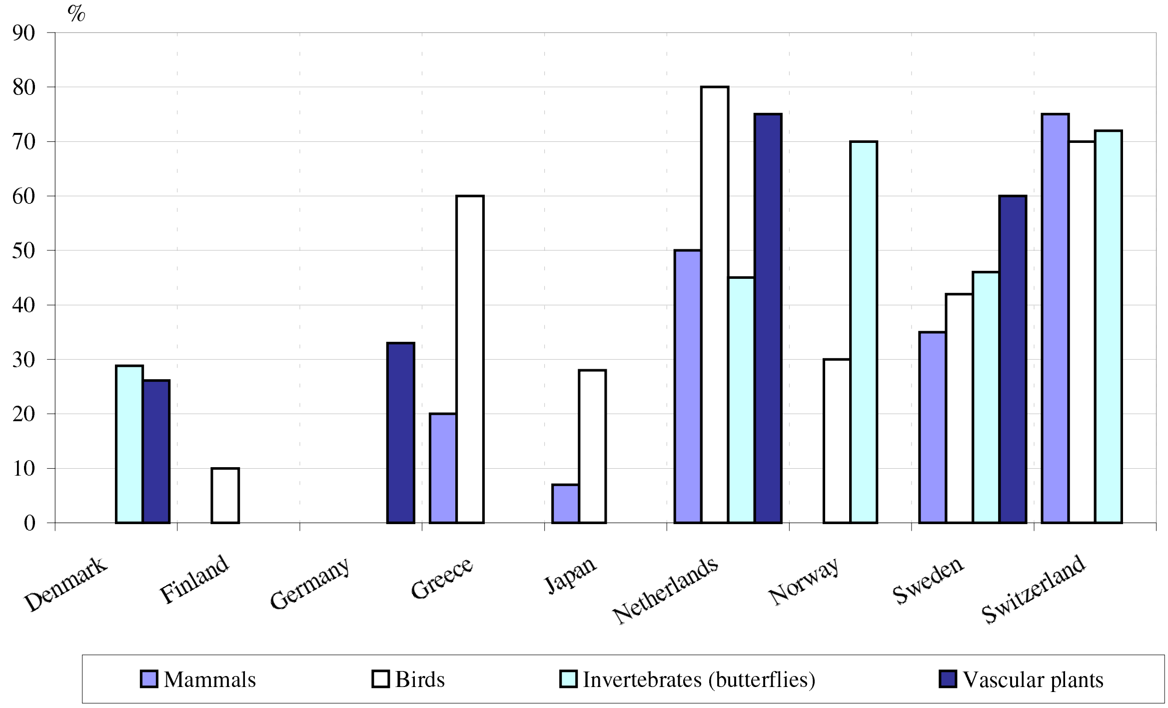


Notes: Data are not available for all livestock categories and all countries.

1. Poultry are not included in the figure as there was no change in the number of breeds registered or certified for marketing between 1985 and 1998, except for Poland, minus 1%.
2. Greece and Netherlands are not included in the figure as there was no change in the number of breeds registered or certified for marketing between 1985 to 1998, except for cattle, minus 11% in the Netherlands.
3. Percentages equal zero for Austria (pigs), Norway (sheep, goats).

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 303, Publications Service, Paris, France.

Figure 9. **Share of selected wild species categories that use agricultural land as habitat[1]: 1998**



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

1. This figure 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 is not dependent on it).

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 308, Publications Service, Paris, France.

The main agents impacting negatively on EU biodiversity since the early 1980s included both increases and intensification of crop production, with a greater use of inputs and less diversified crop rotations, i.e. an increase in wheat, oilcrops and a reduction in secondary cereals, such as oats and rye. The area of permanent crops and pasture also declined, in some cases involving the ploughing up of meadows leading to the removal of habitat features such as hedges and other field boundaries. The overall consequence of these changes was an increase in diffuse pollution through the greater use of chemical inputs, and the removal of habitat, to the detriment of wildlife (Commission of the EC, 1999a).

In most EU countries implementation of measures under Regulation (EEC) No. 2078/92 have sought to preserve biodiversity and habitats, for example, by the introduction of organic farming, integrated crop management, set aside of field margins, and specific measures aimed at particular habitats. Measures are also in place to manage farm woodlands, wetlands and hedgerows to benefit flora and fauna. In addition, the policy of taking land out of production, 'set-aside', has resulted in an increase in fallow land from around 1 million hectares in the early 1980s up to over 4 million hectares by the mid-1990s (European Commission, 1999a). While it is still too early to make any overall assessment of the impacts of these changes on the environment in the EU, evidence from certain Member states would suggest that some environmental improvements have been achieved, especially the restoration of habitats (Figure 10).

Non–native species, which can include a range of plants, vertebrates, invertebrates and pathogens, can inflict considerable financial losses to farmers through damage to crops and competition for livestock forage, and through predation leading to the destruction and decline of native species. However, in some cases these species can be beneficial to agriculture helping to increase food production or for biological control purposes.

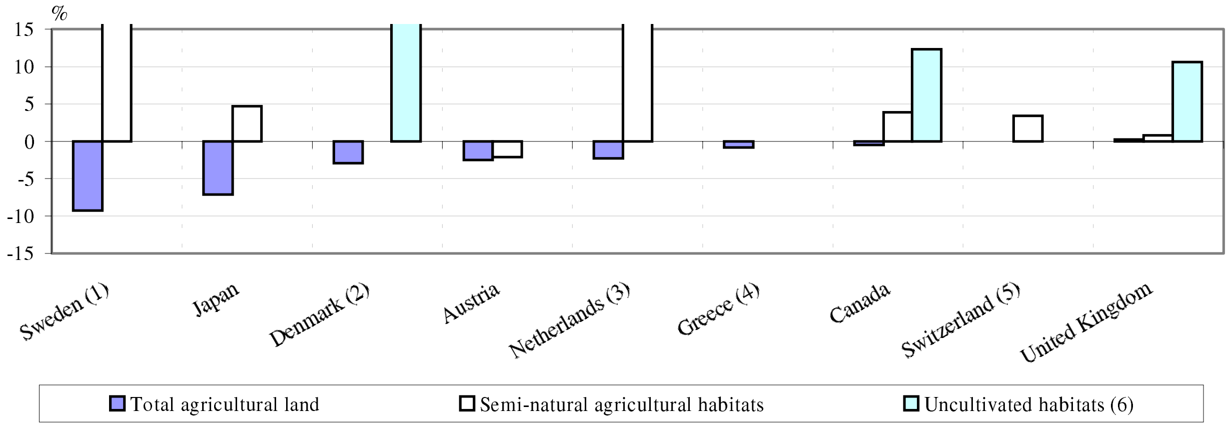
The EU's 6th EAP (Commission of the European Communities, 2001a, p30) observes that "there are concerns about the potential risks to biodiversity from undesired and unforeseen consequences of the introduction of certain non-native species which are not well suited to the local conditions…". For example, in Denmark, mink are a menace to poultry and fish farms, and in Germany the muskrat *(Fiber zibethicus)* has damaged water banks and endangered cultivated plants. Problems elsewhere include those from rats and locusts in Greece; crabfish (*Procambarus clarkii*) in rice fields in Portugal. Certain invasive weeds are also common across Europe, including in Denmark damage to pasture by *Heracleum pubescens* and *rosa rugosa;* in Germany imported crop species, such as tobacco, potatoes and tomatoes have been accompanied by specific pests and viruses; while Greece has reported *Ipomoea hederacea* (ivy-leaf morning glory) and *Eleusine indica* (wire grass) (OECD, 2001b, p314).

iv. Landscapes

As agriculture is the major land-using activity in the EU its impact on landscape is significant. Because landscapes are often not valued in monetary terms, the challenge for policy makers is to judge the appropriate provision of landscape. Also to assess which landscape features society values, and examine to what extent policy changes affect agricultural landscape.

Agricultural landscapes are the visible outcomes from the interaction between agriculture, natural resources and the environment, and encompass amenity, cultural, and other societal values. Landscapes can be considered as composed of three key elements: *landscape structures* or appearance, including environmental features (e.g. habitats), land use types (e.g. crops), and man-made objects or cultural features (e.g. hedges); *landscape functions*, such as a place to live, work, visit, and provide various environmental services; *landscape values*, concerning the costs to farmers of maintaining landscapes and the value society places on agricultural landscape, such as recreational and cultural values (OECD, 2001b).

Figure 10. **Change in the area of total agricultural land, semi-natural agricultural habitats and uncultivated habitats: 1985 to 1998**



Notes: For some countries, the area of semi-natural or uncultivated habitats are unavailable, and not all data cover the period 1985 to 1998.

1. Area of semi-natural habitat showed an increase of 33%.
2. Area of uncultivated habitat includes only woodland which showed an increase of 21%.
3. Area of semi-natural habitat showed an increase of 547%.
4. Negligible change in semi-natural habitat area.
5. No change in agricultural land area.
6. Uncultivated natural habitat (e.g. woodlands, small rivers, wetlands). For Canada, it includes man-made features (e.g. farm buildings, etc.) on and/or bordering agricultural land.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 343, Publications Service, Paris, France.

Regarding the ***current state and trends in the structure of agricultural landscapes*** there does seem to have been a trend towards increasing homogenisation of landscape structures in EU countries over the past 50 years, including the loss of some cultural features (e.g. stone walls). This trend appears closely related to the structural changes and intensification of production., but since the late 1980s, the process toward increasing homogeneity of landscapes could be slowing or in reverse in some regions (Table 1).

To establish the ***value the public places on landscape*** some EU countries use public opinion surveys, although these surveys are limited. Non–market valuation techniques are also used, and studies in EU countries using these techniques reveal that agricultural landscapes are highly valued in many cases, although there is a large variation in the values estimated. These studies also reveal that the landscape surveyed today is the preferred landscape, landscape's value decreases with greater distance from a particular site, heterogeneity and 'traditional' elements are given a higher value over more uniform and newer landscapes, while landscapes perceived as overcrowded have a low value (OECD, 2001b, pp.381-4).

EU countries national agricultural acts typically set ***objectives for the protection and restoration of landscapes*** and provide public access to these landscapes. Also under EU Regulation No. 2078/92, support is provided to farmers who adopt "farming practices compatible with the requirements of protection of the environment and natural resources, as well as maintenance of the countryside and the landscape" (e.g. the Environmentally Sensitive Area Schemes, see Bonnieux and Weaver, 1996). Regulatory measures are also used to set minimum standards on the whole agricultural area and designate certain areas of 'high' landscape value, such as national parks, and impose restrictions on some farm management practices in these areas (e.g. the national park system created in France, see Bonnieux and Rainelli, 1996); or protect specific landscape features (e.g. the Hedgerow Regulations in the UK).

The EU's 6th EAP (Commission of the European Communities, 2001a) notes that "at Community level, regional and agricultural policies need to ensure that landscape protection, preservation and restoration is properly integrated into the objectives, measures and funding mechanisms….On the wider scene, the European Landscape Convention foresees measures to identify and assess landscapes, to define quality objectives for landscapes and to introduce the necessary measures."[4]

2. Reducing Environmental Pollution from Agriculture

Flows of materials into water (e.g. nutrients, pesticides) and emissions into the air/atmosphere (e.g. ammonia, greenhouse gases, ozone depleting substances) are an inevitable part of agricultural production systems. Reducing the flows of these materials and emissions to an 'acceptable' level of risk in terms of human and environmental health is a priority for policy.

i. Water Quality

The EU is addressing issues of water pollution from agriculture through both the EU Nitrate Directive and the Drinking Water Directive, which are now encompassed more broadly under the EU Water Framework Directive. Nearly 15% of EU farms, and over 20% of the agricultural area under agri-environmental programmes, include various restrictions on farmers use of farm chemicals and livestock waste disposal, to help toward improve their environmental performance regarding water pollution.[5]

[4] For details of the newly signed (October 2000) European Landscape Convention, see the Council of Europe web site: http://conventions.coe.int/treaty/EN/Treaties/Html/176.htm

[5] Soil sediment flows from farms into rivers, lakes, and reservoirs are an important source of water pollution in some EU regions, although in most cases information is incomplete on this issue. In Italy, for example, annual storage in reservoirs and dams due to soil sedimentation is considered to be significant, see OECD (2001b, p.267).

Table 1. **Cultural landscape features on agricultural land: 1985 to 1998**

	Unit	1985	1990	1995	1998
Denmark[1]					
Quantity					
- Farm buildings, farm yards	Hectares	..	..	80 000	..
- Hedgerows, ditches and field roads[2]	Hectares	..	..	c. 120 000	..
- Burial mounds (tumuli)	Numbers	..	..	c. 30 000	..
Greece					
Quantity					
- Terraces	Hectares	..	..	250 000	..
Japan					
Quantity					
- Paddy fields (terraced + in valleys)	Hectares	220 000	..	..	..
Norway					
Quantity					
- Buildings from before 1900 that are associated with agricultural activities	Numbers	..	..	..	540 000
- Legally protected buildings associated with agricultural activities	Numbers	..	..	..	c. 2 250
- Summer mountain farms with dairy production[3]	Numbers	..	2 563	2 635	2 719
Poland					
Quantity					
- Group of trees	Numbers	2 611	3 193	4 222	4 482
- Old isolated trees	Numbers	10 035	18 876	26 423	30 811
- Tourist tracks	Km	25 873	28 355	26 725	..
Spain					
Quantity					
- Dehesas[4]	Hectares	1 400 000	..	..	..
- Transhumance tracks	Km	125 000	..	..	..
United Kingdom[5]					
Quantity[6]					
- Banks / grass strips (GB)	Km	57 600	59 800	..	..
- Dry stone walls (GB)	Km	210 300	188 100	..	..
- Managed hedgerows (E&W)	Km	563 100	431 800	377 500	..
- Relict hedgerows (GB)	Km	52 600	83 100	..	..
- Lowland ponds (GB)	Numbers	239 000	230 900	228 900	..
Quality					
- Dry stone walls (E)[7]	% in poor condition	..	..	51	..

c. circa; .. not available.

Notes:

1. Denmark includes 14th and 15th century churches as cultural landscapes features in agricultural areas.
2. Hedges are measured in terms of area, rather than length, as they usually consist of 3-7 rows of trees and large bushes.
3. Number of farms that own or have a share in a mountain farm are determined from the applications made for production subsidies for summer-mountain farming with dairy production with a minimum of 4 weeks.
4. Dehesas refer to wooded pastures and open grassland, used for grazing, crop cultivation and forest products.
5. E: England, W: Wales, GB: Great Britain.
6. Data for 1985 and 1995 refer respectively to 1984 and 1996. The data on length of linear features and number of ponds are net figures for the units defined, for example, for hedges the net figure is the balance between the numbers removed and the numbers of new hedges planted or restored.
7. The percentage refers to the year 1993.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 377, Publication Service, Paris, France.

A key area of concern regarding agriculture and water quality relates to ***nitrate pollution*** in surface and groundwater and ***phosphorus levels*** in surface water. An excessive level of agricultural nutrients in water is a human health concern since it impairs drinking water quality and can cause eutrophication (i.e. algae growth and oxygen shortages in water). Agriculture is the major source of nitrates and phosphates that pollute aquatic environments in most EU countries, accounting for more than 40% of all sources of nitrogen emissions and over 30% of phosphorus emissions into surface water (Figure 11). The extent of groundwater pollution from agricultural nutrients is less well documented, while correlating nutrient contamination of groundwater with changes in farming practices and production systems is difficult, because it can take many years for nutrients to leach through soils into aquifers.

Given the marked reduction in EU ***nitrogen surpluses*** since the mid-1980s, the problems of nitrate pollution of water could start to improve (Figure 12). This has been due to a combination of factors, varying in degree across different countries, including the reduction in dairy cattle numbers linked to milk supply control policies;. Also important has been the removal of arable land under the EU's set-aside scheme; and specific policies aimed at reducing nitrogen surpluses from livestock farms and at limiting inorganic fertiliser use (OECD, 2001a; and Romstad, 1997).

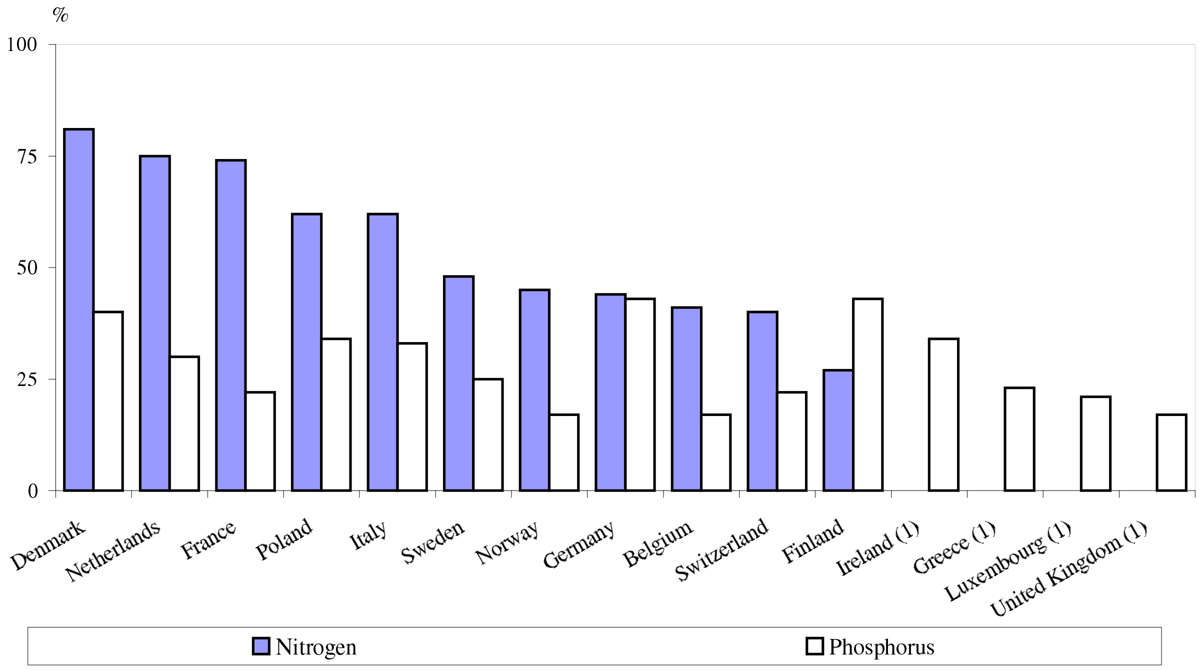
The EU average nitrogen surplus at 58 kg nitrogen per hectare (kg N/ha) of agricultural land, however, is more than double the OECD average of 23 kgN/ha, and compares to 31 kgN/ha in the US (Figure12). Even so, there is considerable ***regional variation in nitrogen surpluses across the EU***. A study by Brouwer, *et al* (1999) suggests that nitrogen surpluses remain below 50 kgN/ha on almost 50% of the agricultural land in the EU, exceeds 100 kg N/ha on a further 22%, and is in excess of 200 kg N/ha on only 2% of agricultural land. While in France, for example, the range of nitrogen surpluses is between 6 kg N/ha in Limousin up to 120 kg N/ha in Brittany, with the national average just over 50 kg N/ha.

It is also noticeable that the overall decline in the total EU nitrogen surplus, both in absolute terms and as a share of the total agricultural area, was mainly due to the reduction in inorganic fertiliser use (nitrogen input), while the production of harvested crops (nitrogen output, e.g. cereals, oilseed crops, etc.) increased (Figure 13). These diverging trends might also indicate the ***improving efficiency in the use of fertilisers*** per unit volume of crop output, partly revealed through the improvement in the EU's nitrogen use efficiency (i.e. the ratio of nitrogen output to nitrogen input). Over the same period, the downward trend in livestock manure production (nitrogen input) revealed a much lower rate of decline relative to inorganic fertiliser (Figure 13). This development was mainly attributed to the fall in EU cattle numbers, with some reduction in pig numbers, partly offset by increasing poultry, sheep and goat populations.

The decline in nitrogen surpluses from EU agriculture is projected to continue up to 2020 (OECD, 2001c). This is because increases of nitrogen output from livestock manure will be more than compensated by greater nitrogen uptake from higher crop production and improvements in fertiliser use efficiency (Figure 14). These gains could be largest in the EU compared to most other OECD countries, mainly because overall levels of nitrogen surplus are higher than in many other countries and also the livestock sector is projected to grow more rapidly in other OECD countries (Figure 5).

Water quality has also benefited from the ***reduction in EU pesticide use*** by 24% between 1985 to 1997 (Figure 15). The expansion in organic farming and uptake of integrated pest management explains, in part, the reduction in EU agricultural pesticide use, but the decrease in the cultivated agricultural area through agricultural land diversion schemes and the switch to area payments has also been an influence. There are a large number of pesticides available for farmers to use, with over 700 pesticide products (active ingredients) marketed in the EU, each of which poses unique environmental and health risks.

Figure 11. **Share of agriculture in total emissions of nitrogen and phosphorus into surface water: mid-1990s**



Note:

1. Data for nitrogen emissions are not available.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 236, Publications Service, Paris, France.

Figure 12. **Soil surface nitrogen balance estimates: 1985-87 to 1995-97**

Change in the nitrogen balance
kg/ha of total agricultural land

Nitrogen balance
kg/ha of total agricultural land

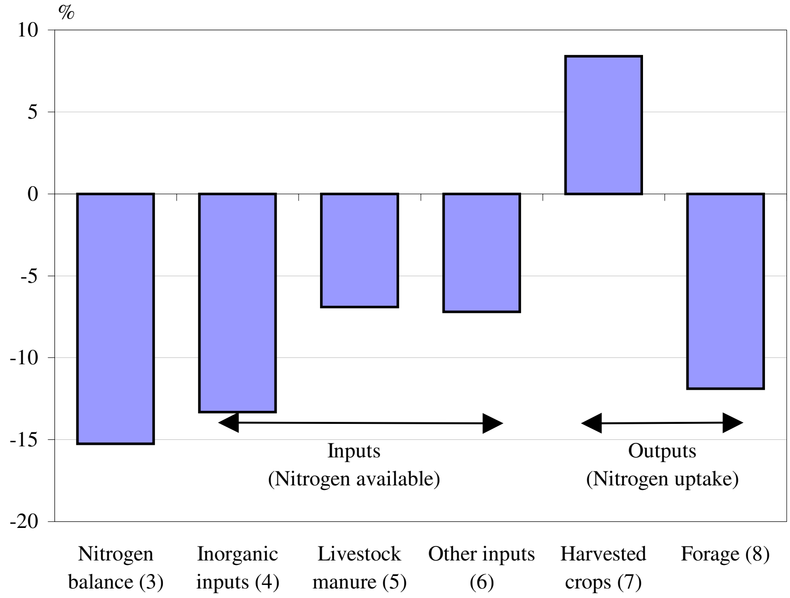
	1985-87	1995-97
Canada	6	13
Korea	173	253
New Zealand	5	6
Ireland	62	79
United States	25	31
Australia	7	7
Portugal	62	66
Norway	72	73
Spain	40	41
OECD	23	23
Iceland	7	7
Belgium	189	181
Japan	145	135
France	59	53
EU-15	69	58
Netherlands	314	262
Finland	78	64
United Kingdom	107	86
Austria	35	27
Denmark	154	118
Switzerland	80	61
Mexico	28	20
Sweden	47	34
Turkey	17	12
Italy	44	31
Germany	88	61
Greece	58	38
Poland	48	29
Czech Republic	99	54
Hungary	47	-15

Notes: While these calculations have been derived from using an internationally harmonised methodology, nitrogen conve coefficients can differ between countries, which may be due to a variety of reasons. For example, differing agro-ecolo conditions, varying livestock weights/yield, and differences in the methods used to estimate these coefficients. Also o part of the calculation is the atmospheric deposition of nitrogen which is mostly independent from agricultural activiti

1. OECD averages, excluding Luxembourg.
2. The 1995-97 average refer to 1995.
3. EU-15 averages, excluding Luxembourg.
4. Including eastern and western Germany for the whole period 1985-97.
5. Data for the period 1985-92 refer to the Czech part of the former Czechoslova

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 123, Publications Service, Paris, France.

Figure 13. **Decomposition of changes in the European Union[1] nitrogen balance[2]: 1985-87 to 1995-97**



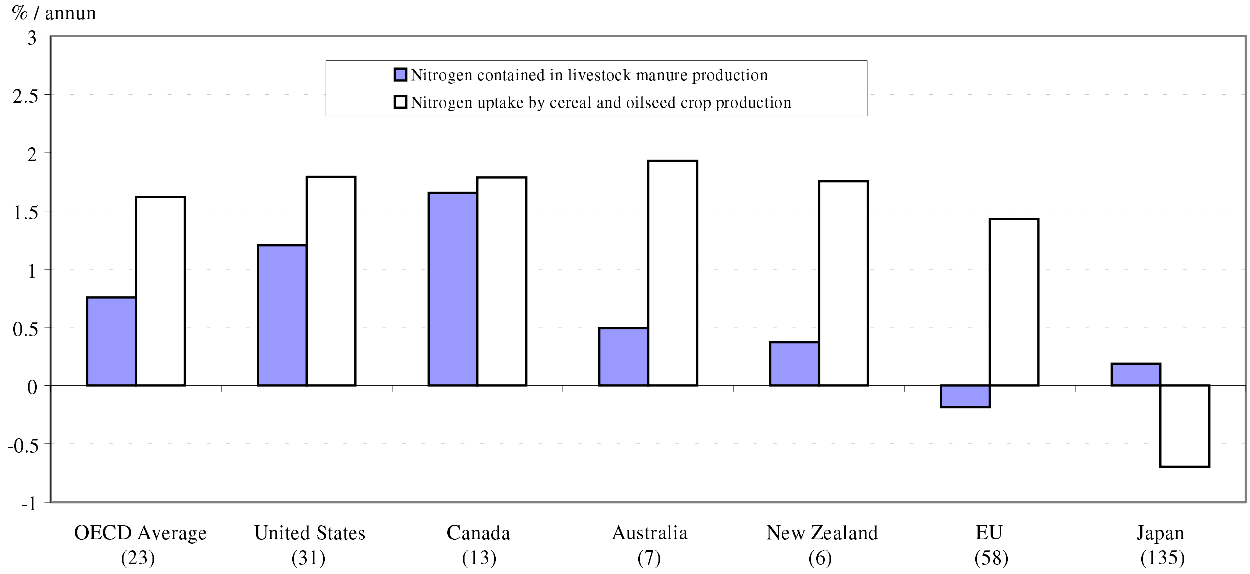
	1985-87	1995-97
	kg / ha	
Nitrogen balance	69	58
	million tonnes	
Inorganic inputs	11.1	9.6
Livestock manure	6.7	6.2
Other inputs	4.2	3.9
Harvested crops	5.3	5.8
Forage	6.8	6.0

Notes:

1. EU-15 averages, including western and eastern Germany, but excluding Luxembourg.
2. Preliminary estimates.
3. Nitrogen balance: nitrogen in kilograms per hectare.
4. Inorganic inputs: includes inorganic nitrogen fertiliser.
5. Livestock manure: nitrogen content of manure production minus volatilisation of ammonia from livestock housing and manure storage.
6. Other inputs: includes biological nitrogen fixation, atmospheric deposition, organic fertiliser, and seeds and planting materials.
7. Harvested crops: includes nitrogen uptake from annually harvested cereals, oil crops, pulses, industrial crops, other crops, and permanent crops (e.g., apples).
8. Forage: includes nitrogen uptake from harvested forage crops (e.g., silage maize) and pasture.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 125, Publications Service, Paris, France.

Figure 14. **Projections for nitrogen production from livestock manure and nitrogen uptake by cereal and oilseed crops[1], OECD countries**



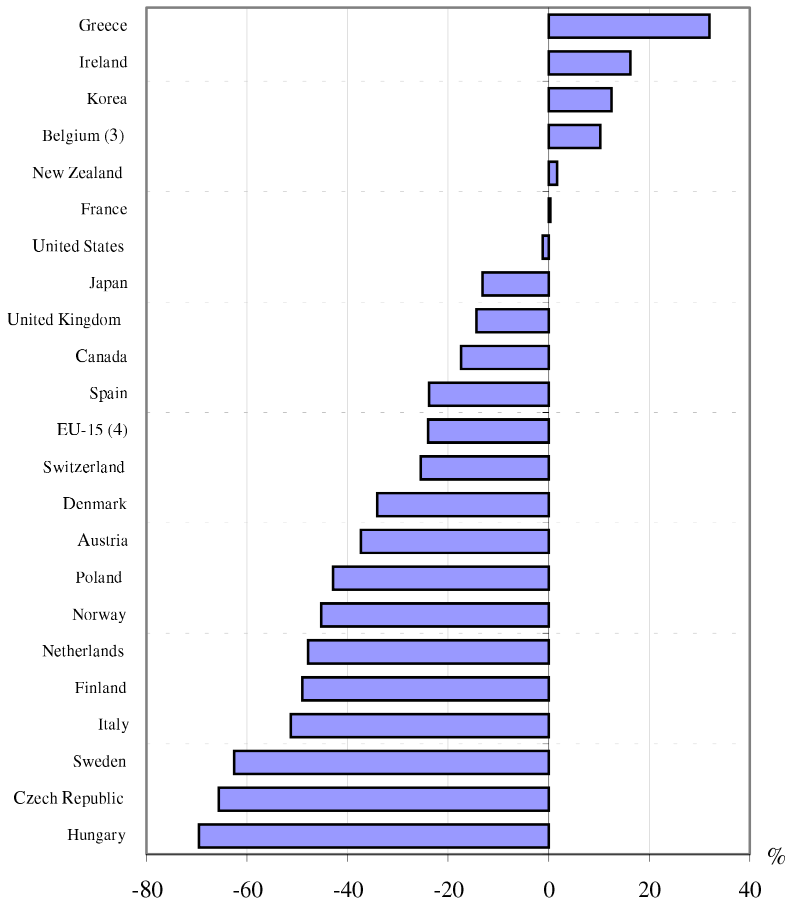
Notes: Figures in brackets are the nitrogen balance in kilogrammes per hectare of total agricultural land, 1995-97.

1. Cereals include: rice, wheat and coarse grains. Oilseeds include: soyabeans, rapeseed and sunflowerseed.

Source: OECD (2001), OECD Agricultural Outlook 2001-2006, Publications Service, Paris, France.

Figure 15. **Pesticide use in agriculture: 1985-87**[1] **to 1995-97**[2]

Change in tonnes of active ingredients



Tonnes of active ingredients[5]

	1985-87	1995-97
Greece	6 928	9 143
Ireland	1 812	2 107
Korea	22 276	25 063
Belgium	8 806	9 710
New Zealand	3 690	3 752
France	96 897	97 229
United States	377 577	373 115
Japan	97 672	84 850
United Kingdom	40 768	34 910
Canada	35 370	29 206
Spain	41 592	31 704
EU-15	333 804	253 684
Switzerland	2 456	1 832
Denmark	6 144	4 051
Austria	5 670	3 552
Poland	15 107	8 628
Norway	1 455	797
Netherlands	20 241	10 553
Finland	1 962	1 001
Italy	99 100	48 270
Sweden	3 885	1 454
Czech Republic	11 217	3 860
Hungary	28 359	8 628

Notes: Some caution is required in comparing trends across countries because of differences in data definitions and coverage.

1. Data for 1985-87 average cover: 1986-87 average for Greece, Korea, and Spain; 1985 for New Zealand; 1985-86 average for Austria; 1987 for Italy; 1988 for Ireland and Switzerland; and 1989 for the Czech Republic.
2. Data for 1995-97 average cover: 1994-95 average for Hungary; 1994-96 average for Switzerland; 1995-96 average for Italy; 1991-93 average for the United States; 1994 for Canada; and 1997 for New Zealand.
3. Includes Luxembourg.
4. Excludes Germany and Portugal.
5. The following countries are not included in the figure: Australia, Germany, Iceland and Mexico (time series are not available); Portugal (data are only available from 1991); and Turkey (data are only available from 1993).

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 147, Publications Service, Paris, France.

With respect to ***risks to water quality from pesticide use***, however, a recent French study found that, while more than a hundred products are detected at variable concentrations and frequencies in water, most of the water pollution from pesticides in France is caused by about ten products. These are mainly herbicides belonging to the triazine family (IFEN, 1998). Moreover, results of pesticide sampling in groundwater across a number of EU countries, found a considerable number of sites with pesticide concentrations >0.1μg/l (microgram per litre), which is the maximum admissible concentration of pesticides specified in the EU Drinking Water Directive (EEA, 1998, pp. 187-191). Given the projected slowdown in EU crop production up to 2020, compared to the 1990s, the recent decline in pesticide use is expected to continue, which suggests that in many countries water pollution from pesticides may be further reduced. But the long time lag between pesticide use and their detection in groundwater means that the situation could deteriorate before it starts to improve.

Estimates of the ***costs of agricultural pollution of water***, suggest that reductions in pollution levels could bring significant benefits. In the United Kingdom, for example, the annual external cost of water pollution in 1996 was estimated at GBP 231 million (US$ 360 million), of which just over half was the cost of removing pesticides from drinking water, although the benefits from higher yields through using pesticides was not calculated (Pretty, *et al* 2000). Much of the remaining cost of water pollution in the UK was as a result of the costs of removing nitrates and phosphates from drinking water, and also eutrophication problems linked to nutrient loadings of rivers and lakes.

The WWF (2001) has concluded that although the situation of EU water pollution is slowly improving, diffuse pollution from agriculture is still a widespread problem. The EU's new Water Framework Directive, which strengthens existing EU water legislation, is seen by WWF as a major piece of legislation that could make a significant contribution to improving water quality. WWF (2001, p.7) also concludes that "most European countries have inadequate environmental monitoring systems to properly safeguard their water resources … [including] a lack of reliable data on diffuse pollution (nitrates, phosphates, pesticides and other contaminants), which is responsible for significant impacts on ecosystem health and the quality of drinking water resources…."

ii. Pesticides, human health and wildlife

Pesticides are also of concern in terms of other human health risks and impacts on wildlife. The ***health risks to those applying pesticides*** in the field and in close proximity to land treated with pesticides is poorly documented across EU countries (OECD, 2001b, p.161). For countries where information is available the extent of the problem appears small, and likely to decline further with improvements in application practices, education and training, and technologies used to apply pesticides.

Levels of ***pesticide residues in foodstuffs*** for most countries are below current maximum permissible levels, although on occasions these limits are exceeded for fruit and vegetables. Evidence from EU countries reveals that in 36% of samples, pesticide residues at or below the minimum residue levels were detected in samples of fruit, vegetables and cereals. In over 3% of all samples, residues above the EU maximum residue limits were found, mainly in fruit and vegetables (European Commission, 1999b).

There remain, however, considerable scientific uncertainties related to the possible risks associated with ***pesticide use and endocrine disruption***. Increasingly research is showing that the chemicals in some pesticides, and other chemicals (e.g. detergents), are disrupting human and wildlife endocrine systems or hormonal systems, with harmful impacts on human and wild species fertility and pregnancy. This problem has provoked the EU to develop a Community strategy for endocrine disrupters, including pesticides, which is a development in common with other OECD countries, such as the United States (Commission of the EU, 1999b; and US Environmental Protection Agency, 2000).

The impact of pesticides on wildlife is also poorly reported in most EU countries. However, where adverse effects occur these could diminish as farmers substitute more broad scale for narrow spectrum pesticides, and increasingly use precision farming technologies to apply pesticides. This should help to avoid harmful impacts on beneficial wildlife, such as pollinators, and non-target flora and fauna.

iii. Air pollution and climate change

One of the main ***air pollutants*** from agricultural activities is ***ammonia*** (NH_3), which can lead to damaging effects on plant foliage growth, soil acidification and eutrophication. Evidence for some European countries indicates that around 95% of ammonia emissions into the air result from agricultural activity, with about 60% from animal manure (particularly cattle) and much of the remainder from the use of inorganic nitrogen fertilisers (OECD, 2001b, p.128). Projections of livestock production and fertiliser use would suggest that ammonia emissions from agriculture up to 2020 are expected to decline in the EU (OECD, 2001c).

It is estimated that ***methyl bromide*** accounts for 5-10% of the global loss of stratospheric ozone, and may be responsible for around 20% of the Antarctic ozone depletion (Mano and Andreae, 1994). According to research by Mano and Andreae (1994), agricultural pesticide use as a source of methyl bromide accounts for 25-60% of total annual global emissions. Grassland and forest fires also provide a major contribution of around 30% to the annual stratospheric bromine budget. Developed countries account for about 80% of methyl bromide use worldwide, and in the EU 90% of total methyl bromide use is for soil fumigation (EUROSTAT, 1999, p.91).

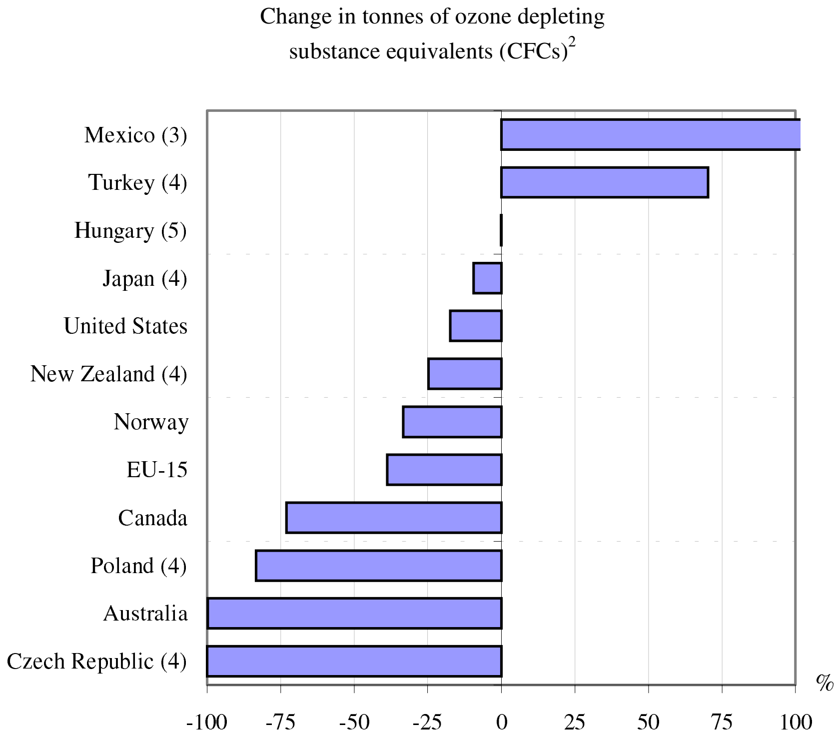
The EU has reduced its use of methyl bromide pesticide by nearly 39% over the 1990s, as agreed under the Montreal Protocol for the Protection of the Ozone Layer (Figure 16). In the EU there are large differences in the use of methyl bromide, with its use mainly concentrated on open field fruit and vegetable production in Italy and Spain. In Austria, Denmark, Finland, Germany, Luxembourg, the Netherlands and Sweden its use is severely restricted or banned (EUROSTAT, 1999, pp.90-91).

With increased atmospheric concentration of greenhouse gases (GHGs) contributing to the process of ***climate change*** and global warming, the EU together with most other OECD countries, under the 1994 United Nations Framework Convention on Climate Change (UNFCCC), have committed themselves to stabilise emissions of GHGs at 1990 levels by 2000. These countries also agreed to implement the 1997 Kyoto Protocol, which specified the levels of emissions for the target period 2008 to 2012 (these targets cover total national emissions, including the agriculture sector).

Total national gross ***GHG emissions from EU agriculture*** decreased by 2% over the period 1990 to 1997, compared to an increase of 1% in OECD average emission levels, and a rise of 7% for the US (Figure 17). Agriculture only contributes about 11% of total EU greenhouse gas emissions, ranging from a share of 6% in Germany to 34% in Ireland (OECD, 2001b). While the contribution of EU agriculture in the total main GHG gas, carbon dioxide (CO_2), is only about 2%, it accounts for over 50% of total nitrous oxide (N_2O), and nearly 45% of methane (CH_4) emissions. Livestock enteric fermentation, manure and the use of inorganic fertilisers account for the major share of agricultural GHGs in most EU countries.

Projections of agricultural GHG emissions to 2020 reveal a varied picture across OECD countries (Figure 18; Table 2). These estimates are based on projections of livestock and rice production, however, they understate the likely level of agricultural GHG emissions, because a number of emission sources are excluded (due to a lack of data), notably fertiliser use, fossil fuel combustion, biomass burning, and changing farm management practices and land use patterns. They also ignore the possibility of further progress (or failure) to agree to reduce emissions amongst the signatories to the UNFCCC.

Figure 16. **Methyl bromide use[1]: 1991 to 1998**



Tonnes of ozone depletion potential

	1991	1998
Mexico	238	1 207
Turkey	296	504
Hungary	32	32
Japan	3 664	3 318
United States	15 317	12 649
New Zealand	81	61
Norway	6	4
EU-15	11 530	7 056
Canada	148	40
Poland	120	20
Australia	422	1
Czech Republic	6	0

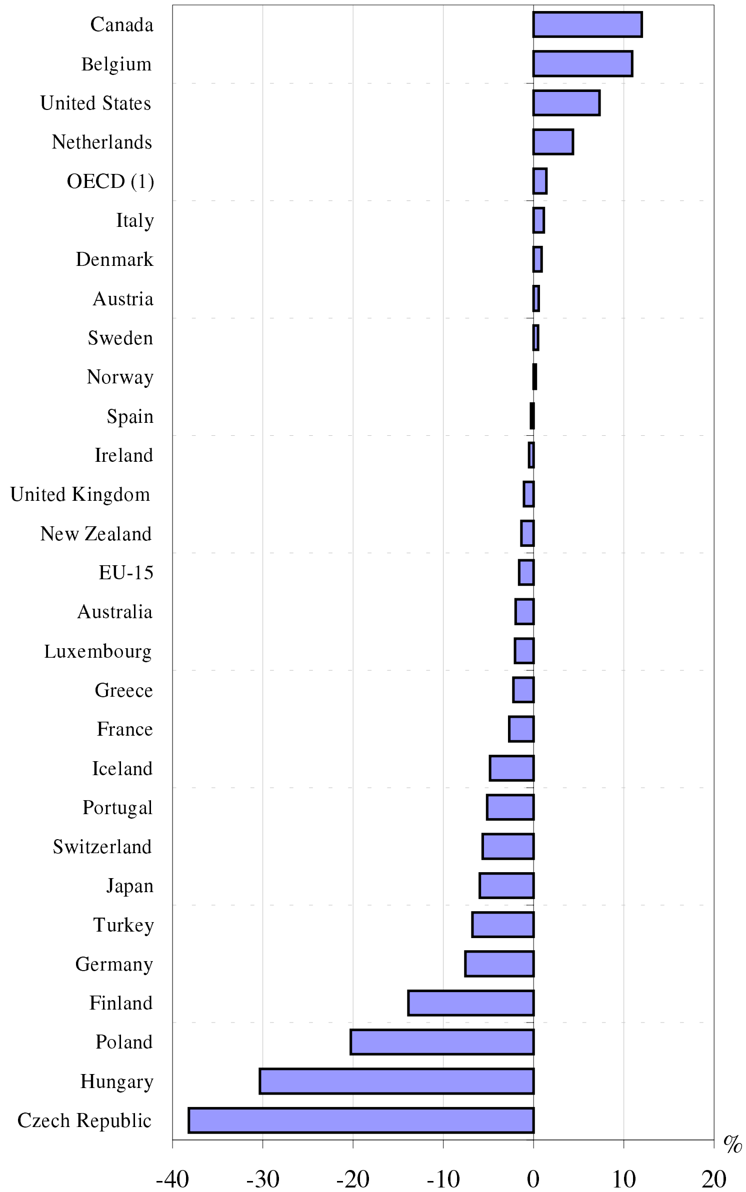
Notes: Methyl bromide is mainly used by agriculture for most countries.The Montreal Protocol for the protection of the ozone layer agreed that for developed countries they should reduce methyl bromide use to 1991 levels by 1995, achieve a 50% reduction by 2001 and phase-out their use by 2005 with the possible exemption for critical agricultural uses.

1. In Austria, Denmark, Finland, Germany, Luxembourg, the Netherlands, Sweden, and Switzerland methyl bromide use is severely restricted or banned and thus are not included in this figure.
2. CFCs: chlorofluorocarbons.
3. The percentage equals 407%.
4. Data for 1998 refer to 1997.
5. The percentage equals 0%.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 163, Publications Service, Paris, France.

Figure 17. **Gross emissions of greenhouse gases from agriculture: 1990-92 to 1995-97**

Change in gross emissions of greenhouse gases from agriculture



Percentage share of agriculture in total GHG

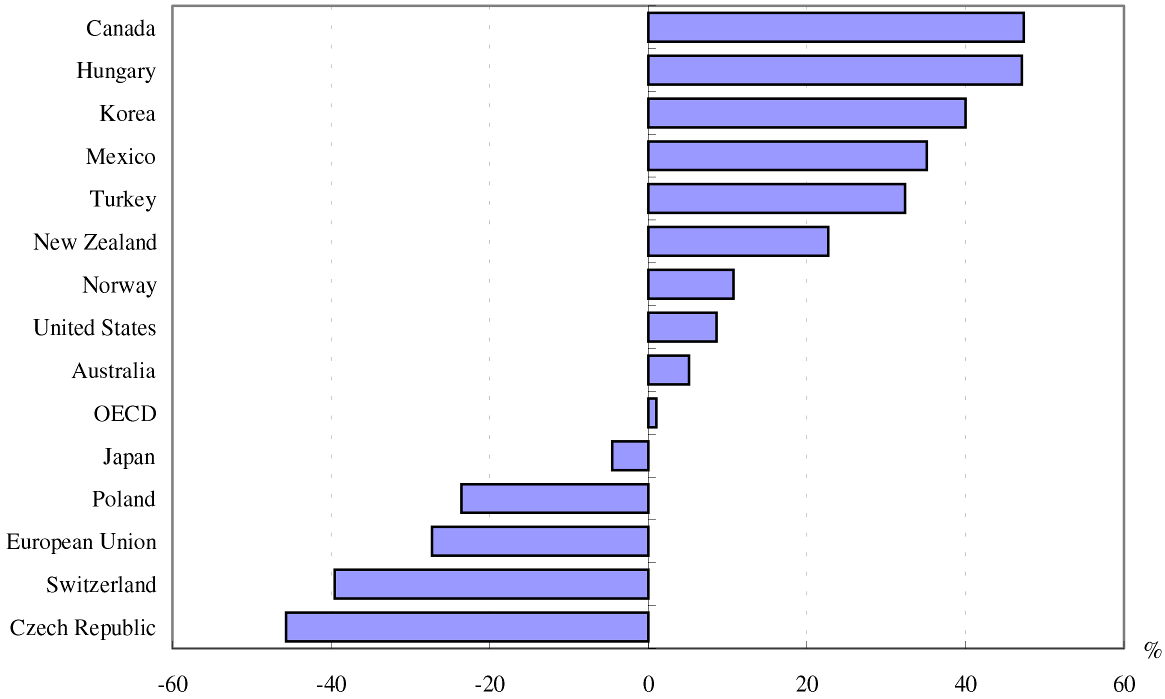
	1995-97
Canada	9.8
Belgium	10.0
United States	7.4
Netherlands	12.2
OECD	8.4
Italy	9.6
Denmark	21.7
Austria	7.0
Sweden	13.7
Norway	9.9
Spain	13.5
Ireland	34.0
United Kingdom	8.1
New Zealand	55.8
EU-15	10.7
Australia	19.5
Luxembourg	4.6
Greece	13.3
France	17.3
Iceland	11.0
Portugal	10.5
Switzerland	10.8
Japan	1.5
Turkey	6.8
Germany	6.2
Finland	8.2
Poland	5.1
Hungary	5.8
Czech Republic	3.3

Note:

1. Korea and Mexico are not included.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 278, Publications Service, Paris, France.

Figure 18. **Projections of Greenhouse Gas Emissions from Livestock and Rice Production, OECD countries, 1990 to 2020**



Source: OECD (2001), OECD Agricultural Outlook 2001-2006, Publications Service, Paris, France.

Table 2. **Agricultural Greenhouse Gas emissions in 1990-92 and projections to 2020, OECD countries**

	Agricultural emissions in 1990-92 million tonnes of CO_2 equivalent	Share of agriculture in total national emissions in 1990-92 (%)	Kyoto protocol commitments for 2008-12 relative to the base period 1990 [1] (%)	Change in estimated emissions (livestock and rice production) to 1990-2020 [2] (%)	Share of livestock and rice production in total agricultural emissions in 1990-92 [3] (%)
OECD	1160	9	n.a.	**1**	56
United States	442	7	-7	**9**	44
European Union (15)	439	11	-8	**-27**	45
Australia	86	21	8	**5**	77
Canada	58	10	-6	**47**	41
New Zealand	42	58	0	**23**	75
Poland	28	6	-6	**-24**	64
Japan	21	2	-6	**-5**	93
Turkey	18	9	n.a.	**32**	96
Czech Republic	8	5	-8	**-46**	53
Hungary	6	8	-6	**47**	56
Switzerland	6	11	-8	**-40**	52
Norway	5	11	1	**11**	41
Korea	..	..	n.a.	**40**	..
Mexico	..	..	n.a.	**35**	..

..: not available; n.a.: not applicable

Notes:

1. For Hungary and Poland, the base periods are 1985-87 average and 1988, respectively.
2. The estimates are based on projections of livestock and rice production.
3. These shares are lower than total agricultural emissions as they do not include emissions from fertiliser use, fossil fuel combustion, biomass burning, and changing farm management practices and land use patterns.

Source: OECD (2001), OECD Agricultural Outlook 2001-2006, Publications Service, Paris, France.

But these projections of GHG emissions, also do not take account of the ***role of agriculture as a sink for GHGs***. Currently there are no systematic estimates across OECD countries of the capacity of agriculture in sequestering (removing) carbon in soils. The carbon sequestration capacity of agriculture is affected by a complex set of relationships, but estimates show that about 50% can be achieved by adopting soil conservation and improving crop residue management (e.g. reduction of stubble burning), 25% by changing cropping practices (e.g. increases in soil cover), and much of the rest through a combination of land restoration efforts and converting cropland to pasture (Antle, *et al*, 1999).

Future changes in sequestering carbon by altering farming practices and production intensity, is thought to increase soil carbon slowly over the first 2–5 years, with larger increases between 5–10 years, reaching a finite limit after about 50 years. Recent trends for some countries indicate a growing number of farmers using conservation tillage practices and increasing the number of days per year the soil has a vegetative cover. In addition, if EU continue to keep agricultural land out of production this could have a positive impact for carbon sequestration depending on how this land is managed in future (OECD, 2001b).

Agriculture also has the potential to reduce GHG emissions through the replacement of fossil fuels with ***biomass energy***, from crops. International Energy Agency (IEA) projections expect non–hydro renewable energy (NHRE) sources (mainly geothermal, solar, wind, tide and biomass) to be the world's fastest growing primary energy source up to 2020 at nearly 3%/annum. Most of this is accounted for by OECD countries, and the contribution of biomass in world total NHRE may decline from nearly 75% to about 50% (IEA, 2000).

Despite the rapid growth in NHRE production the share of these energy sources in total European OECD countries (i.e. EU countries plus Czech Republic, Hungary, Iceland, Norway, Poland, Switzerland and Turkey) electricity production is small but projected to rise from 2% at present to 5% in 2020, with over 45% of this expected to be accounted for by biomass. While concerns over climate change may encourage the production of renewable energy sources they are likely to remain expensive compared to fossil fuels and their development in Europe will continue to rely on policy support to achieve the projected growth rates by 2020 (IEA, 2000).

3. Improving Agri–environmental Management Practices and Resource Use Efficiency

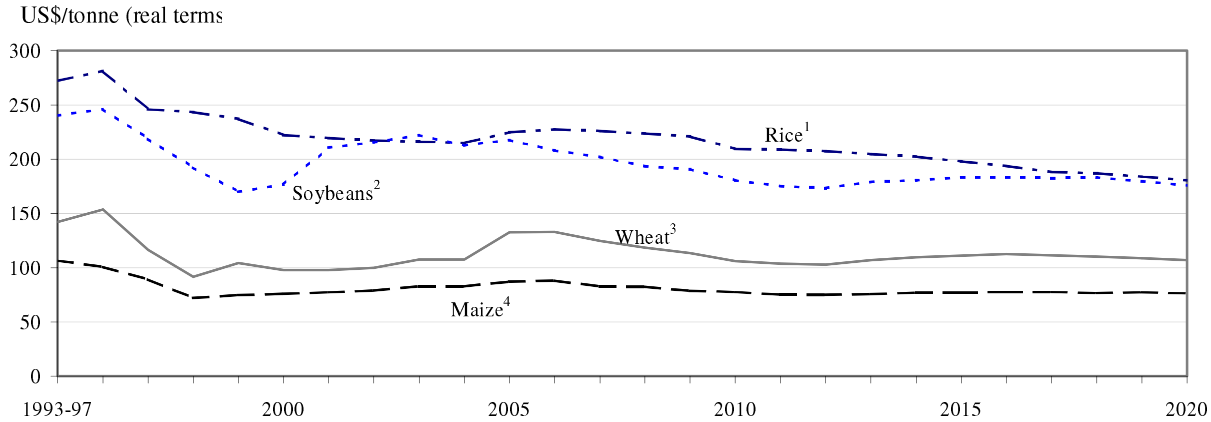
The projected decrease to 2020 in international agricultural commodity prices, in real terms (Figure 19), can be expected to bring pressure on farm incomes and contribute toward further ***structural changes in EU agriculture***, leading to a reduction in the share of agriculture in GDP and total employment. These developments suggest average farm size could increase in terms of area and capital assets for most countries in a move towards further gains in productivity to support agricultural profitability. Major drivers in agricultural profitability and structural change, apart from changes in market conditions, are developments in technologies, farm management practices, and resource use efficiency.

i. Changes in Technologies and Farm Management Practices

Many of the ***technologies and management practices*** available to farmers have the potential to steer agriculture along a sustainable path, providing both economic and environmental benefits (Hrubovcak, *et al.,* 1999). Examples include, precision farming, such as linking global positioning to geographical information systems to map precise fertiliser and pesticide requirements; biotechnology, for example, genetically modified (GM) crops that are insect and herbicide resistant and recombinant bovine somatotropin (rBST) which stimulates milk production in cows; and farm management practices such as enhanced nutrient management, integrated pest management, conservation tillage, and organic farming.

Figure 19. **International agricultural commodity price projections (real terms), 1993-97 to 2020**

Cereal and soybean price projections



Notes:

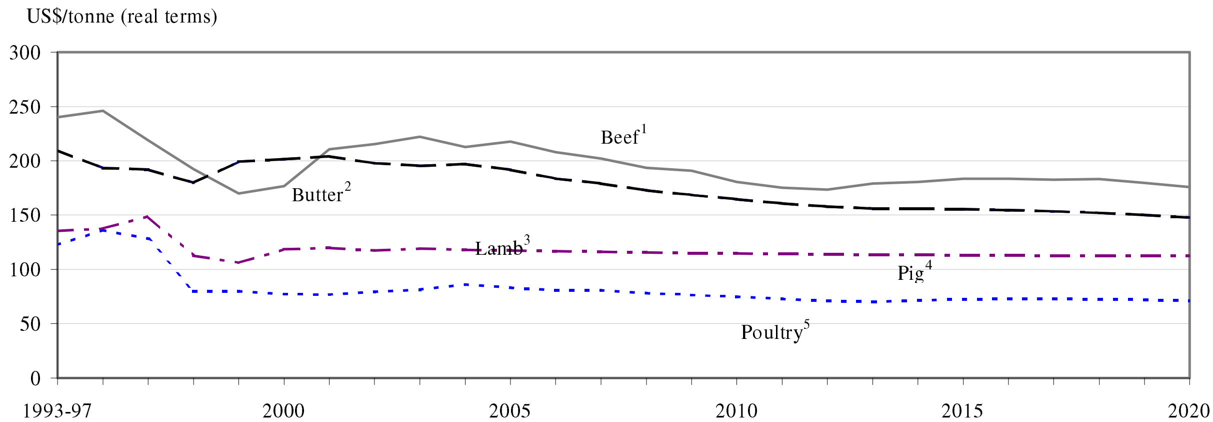
1. Milled, grade b rice, f.o.b. Thailand.

2. US soyabeans, c.i.f., Rotterdam.

3. No. 2 hard red winter, ordinary protein, wheat, US, f.o.b Gulf Ports.

4. No. 2 yellow corn, US, f.o.b., Gulf Ports.

Meat and butter price projections



Notes :

1. Choice steers, 1100-1300 lb lw, United States.

2. F.o.b. export price, 40 lb blocks, Northern Europe.

3. New Zealand lamb schedule price, all grade average.

4. Barrows and gilts, No. 1-3, 230-250 lb lw, Iowa/South Minnesota, United States.

5. Wholesale weighted average broiler price, 12 cities, United States.

Source: OECD (2001), OECD Agricultural Outlook 2001-2006, Publications Service, Paris, France.

The rapid decline in costs for ***information and communications technology***, such as global information systems, global positioning systems and remote sensing is contributing to the adoption and diffusion of precision farming across EU countries. But there is uncertainty on how much further the costs of these technologies will decline relative to the savings from lower input use, whether farmers skills to use these technologies will improve, and, therefore, the extent of environmental impacts that will flow from agriculture's adoption of these technologies.

Adoption of new technologies and management practices by farmers is also heavily dependent on profitability, risk perceptions, and the extent to which the regulatory system restricts the use of certain technologies or particular farming practices. Even where new technologies and management practices are profitable, there can be impediments affecting their rate of adoption and diffusion, for example, the education level and training of farmers and different perceptions of economic risks. Illustrative is the small number of countries where more than 40% of farmers have even basic post-school training (Figure 20).

ii. Resource Use Efficiency: Energy, Fertilisers, Pesticides and Water

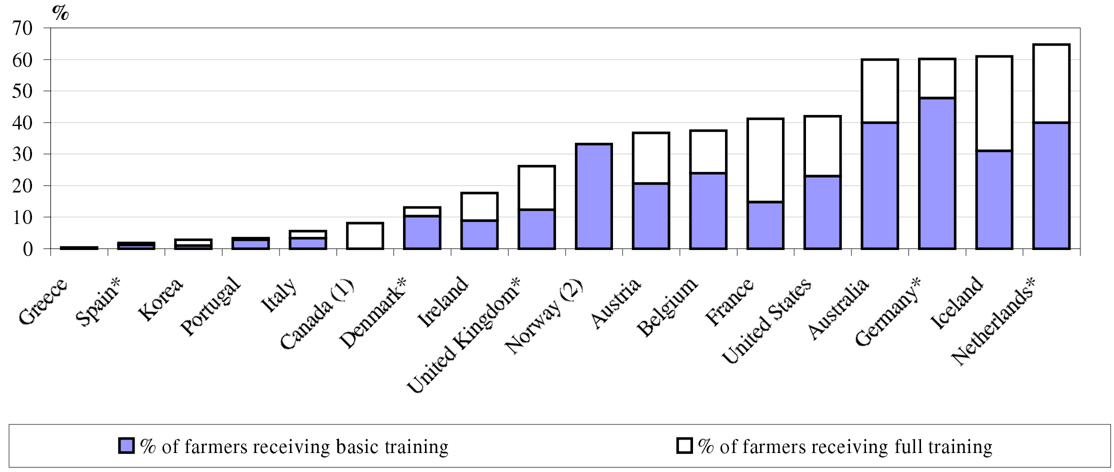
The ***future efficiency of using farm inputs*** *(i.e. energy, fertilisers, pesticides, water)* is important in terms of their potential pressure on the environment and also rates of natural resource depletion. Farm input use efficiency is affected by resource prices (cost relative to farm receipts), the availability and cost of technologies which can improve the efficiency of input use, and the effects of government policies on input use. As ***energy*** is an important element in the manufacturing costs of fertilisers, pesticides, and fuel for farm machinery, the evolution of future fossil fuel prices are critical, but subject to major uncertainties. IEA projections, however, suggest that real fossil fuel prices might remain relatively stable up to 2010, but increase after 2010 in response to supply side pressures (IEA, 2000).

Concerning the ***use of fertilisers and pesticides*** two key trends are likely to emerge in future across EU countries, compared to recent events. First, there is expected to be a slow down in the rate of increase in the use of these inputs, and in some cases an absolute reduction in use. Second, it is anticipated that there will be improvements in the efficiency of using these inputs in terms of the physical quantities used per tonne of output. As a consequence use of these inputs may further decline from the peaks of the late 1970s/early 1980s (EFMA, 2000). This is likely to result from only limited increases in crop production (Figure 5); further restrictions on fertiliser/pesticide use in some cases; the increasing use of livestock manure, recycled crop waste and sewage sludge as a source of crop nutrients; and improvements in input use efficiency. The extent to which EU agricultural support shifts to measures that are not linked to commodity production may also have a bearing on the intensity of using these inputs.

Improvements in ***water use efficiency*** will be important in those EU regions where there is growing competition for water resources between agriculture, household and industrial users, and also the increased demand for reducing water stress on aquatic habitats in rivers and lakes. Certain irrigation technologies (e.g. drip-emitters, booms and pivots) have facilitated a reduction in water use to the minimum levels required by the crop, but this is often accompanied by an increase in irrigated area, so that the overall quantity of water use remains the same (Poiret, 1999). For the few EU countries for which data are available, flooding and high pressure rain guns are the technologies most commonly used to provide irrigation water, rather than the more water use efficient drip emitters, booms and pivots.

While the continued use of farm inputs and adoption of new technologies by farmers will be needed if agriculture is to achieve further improvements in productivity, there are uncertainties about the ***limits to agricultural productivity gains imposed by physical and biological environmental constraints***. Technological improvements and increased input use might be unable to raise agricultural production sufficiently to offset the depletion of soil and water resources. It is also thought that in some regions further intensification of agriculture can induce irreversible changes in ecosystems, once sustainable thresholds of

Figure 20. **Educational level of farmers: mid / late 1990s**



* 1990 data.

Notes:

1. Data not available for basic training.

2. Value refers to both basic and full training.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 45, Publications Service, Paris, France.

natural ecosystems are exceeded, especially soil degradation and depletion of water resources (Brown, 2000; Penning deVries, *et al*, 1995; and Laxminarayan and Simpson, 2000). Other examples of biophysical constraints include loss of agricultural genetic resources, and pest and disease resistance to pesticides.

These concerns, together with other related issues such as food safety and quality, are fuelling a discussion about to what extent ***the future development of organic agriculture in the EU*** could help overcome possible limits to agricultural productivity gains imposed by biophysical environmental constraints. As part of its agri–environmental programme the EU is promoting organic agriculture. While organic farming has grown rapidly over the 1990s, nevertheless, its share of the EU total agricultural area is around 2%, but is over 4% of the agricultural area in Austria, Finland, Italy and Sweden (Figure 21).

The future expansion of organic farming will largely depend on policy incentives, raising yields, lowering producer conversion costs, and reducing consumer prices. A study of France showed that yields for conventional wheat production were about 23% higher than for organic wheat, while in the Netherlands yields of dairy cows under conventional systems were about 11% above those under organic systems (OECD, 2000a; and 2000b). In Canada, research shows that yields of organic maize and soyabean crops can be variable, depending on the manager's skills. During transition to an organic system, yields can be as much as 50% below those under conventional systems, but after a 3–5 year transition period, yields usually climb back to 80–100% of the conventional system (Ontario Ministry of Agriculture, 1998).

A case study from the United Kingdom shows that for a specific farm converting from conventional to organic farming, the gross margins fell by almost GBP 100 (US$ 150) per hectare in the conversion years, but once fully converted, gross margins on organic farms were up to 15% higher than for a similar conventional farm (Cobb, *et al*, 1998; MAFF, 2000). Moreover, consumer prices for organic foods are generally higher than for conventional products, although complete price information on organic foods is poorly documented at present.

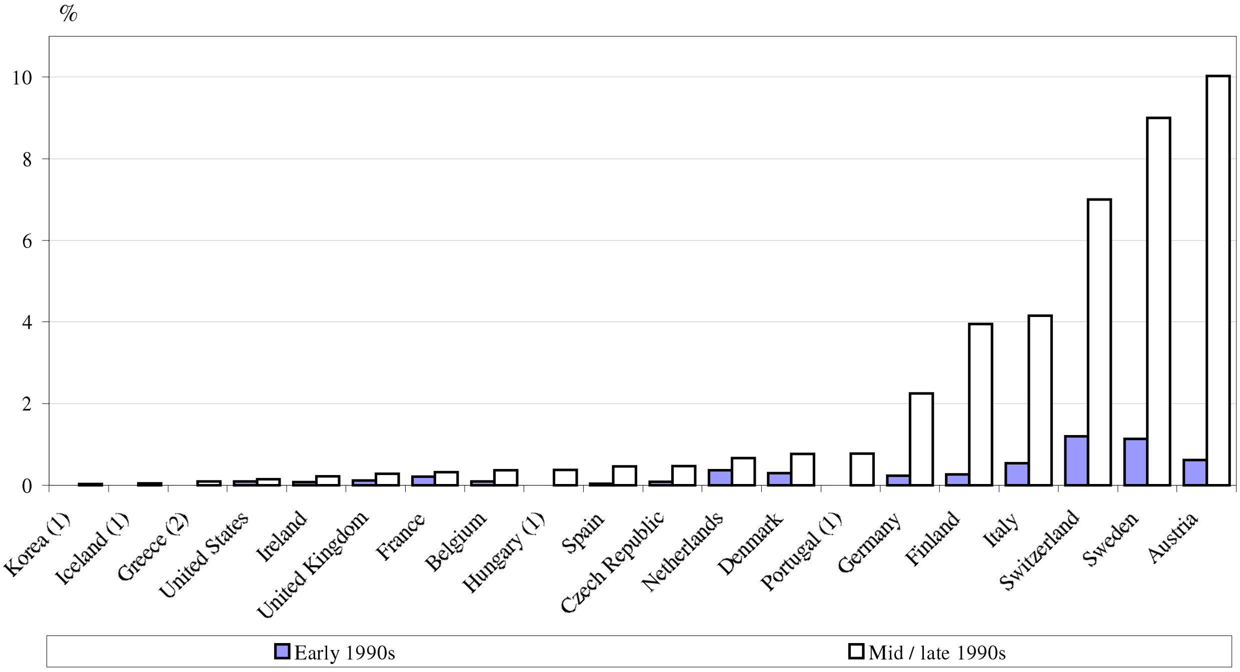
With the current yields obtained under organic farming, a significant expansion of organic farming would involve both an increase in the area under cultivation and animal stocking rates if current production levels were to be maintained. This could conflict with the conservation of biodiversity and habitats if additional 'high nature value' land were brought into production. Moreover, unless the higher prices associated with organic foods are not reduced then this is likely to involve a slower growth in the demand for these products across EU countries over the next 20 years.

The uncertainties surrounding the possible future potential for organic farming relate to the extent to which the productivity of organic systems might improve if the current emphasis of public and private agricultural research expenditure was shifted from conventional to organic farming systems. Also in comparing the yields, costs and prices of conventional versus organic farming, no account is usually taken of the relative environmental costs associated with the two systems in terms of the effects on soil degradation, water depletion and pollution, and effects on human health and wildlife.

III. Future Directions: Indicators As A Tool For Policy Purposes

There is a considerable effort underway to develop agri-environmental indicators to help assess the current state and trends in the environment conditions in agriculture and to provide a tool for policy monitoring, evaluation and projections. A growing number of ***EU Member states*** are seeking to assess the environmental performance of agriculture, including in Denmark (Simonsen, 2000), France (IFEN, 1997, and 2000), and the Netherlands (Brouwer, 1995). For other countries the approach is to examine progress toward sustainable agriculture, including the balance between economic, environmental and social needs, for example, reports completed by Finland (Aakkula, 2000) and the United Kingdom (MAFF, 2000).

Figure 21. **Share of the total agricultural area under organic farming: early 1990s and mid / late 1990s**



Notes:

1. Data for the early 1990s are not available.
2. Percentage for the early 1990s equal 0.003%.

Source: OECD (2001), Environmental Indicators for Agriculture, Volume 3 - Methods and Results, p. 94, Publications Service, Paris, France.

At the ***EU regional level*** various European public institutions are involved in establishing agri-environmental indicators. Most importantly is the request from the EU Council Summit meeting in Helsinki, December 1999, to establish indicators for the integration of environmental concerns into the CAP (Commission of the European Union, 2000). In response, a joint report by the European Commission and EUROSTAT provides statistical information on agriculture, environment and rural development (European Commission, 1999a; and EUROSTAT, 1999). The European Environment Agency is also involved with developing indicators, which include an agricultural focus (EEA, 2000). Other international governmental organisations, such as FAO and the World Bank, and non-governmental organisations, for example, the European Centre for Nature Conservation (2000) and the World Wide Fund for Nature (2000), are also address agricultural issues through the use of indicators.

It will be necessary to build on these initiatives to develop indicators as a tool for policy makers in addressing the different EU policy challenges previously outlined. ***A number of EU institutions have also emphasised the importance of developing indicators*** as one tool for policy purposes:

--"The development of appropriate indicators is essential, if future environment oriented expenditure within the agricultural policy domain is to achieve value for money". (European Communities Court of Auditors ,2000, para. 84).

--"Appropriately developed agri-environmental indicators will be particularly important in improving transparency, accountability and ensuring the success of monitoring, control and evaluation. This will contribute significantly to the effectiveness of policy implementation and feed Global Assessment processes" (Commission of the European Communities, 2000).

--"Sound scientific knowledge and economic assessments, reliable and up-to-date environmental data and information and the use of indicators will underpin the drawing-up, implementation and evaluation of environmental policy" (Commission of the European Communities, 2001a)

To meet the demands for an improved information base on the environmental performance of agriculture for policy makers and the wider public will require:

- ***improving the analytical soundness and measurability of indicators***, such as a better understanding and measurement of agriculture soil carbon sinks, and also how to further develop and refine indicators that track agriculture's impacts on biodiversity, habitats, and landscapes;
- ***overcoming data deficiencies and providing a better interpretation of indicator trends***, especially through better expression of the spatial variation of national level indicators, and developing appropriate baselines, threshold levels and targets to help assess policy performance;
- ***using agri-environmental indicators to better inform policy monitoring, evaluation and projections***, for example, determining the effects of irrigation water and infrastructure support on irrigation management and water use; and,
- ***developing indicators that can help to examine synergies and trade-offs*** between the economic, social and environmental linkages and dimensions of sustainable agriculture.

As well as producing food and fibre, EU agriculture is also increasingly being required to provide various environmental goods and services, such as serving as habitat for wildlife; providing ecological services, for example, acting as a sink for greenhouse gases; and supplying amenities, like attractive landscapes. If EU policy makers are going to be effective in providing the environmental goods and services being demanded from agriculture, then they will benefit from the support of reliable data and indicators. A better understanding and measurement of the links between the environmental, economic and social dimensions of sustainable agriculture will also help to improve policy performance.

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