Environmental Indicators for Agriculture

Methods and Results

EXECUTIVE SUMMARY

2000

OECD

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

– to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;

– to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and

– to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

FOREWORD

The impacts of agriculture on the environment and the achievement of sustainable agriculture are of major public concern in the context of agricultural policy reform, trade liberalisation, and multilateral environmental agreements. This *Executive Summary* accompanies the publication of Volume 3 of the OECD series *Environmental Indicators for Agriculture*. It is a stocktaking of the environmental performance of agriculture considering a range of policy relevant agri-environmental issues in OECD countries. The study aims to review and take stock of progress in developing agri-environmental indicators in OECD countries; build on earlier OECD work in establishing standard definitions and methods of calculation for indicators; provide preliminary results of the state and recent trends of environmental conditions in agriculture across OECD countries; interpret indicator trends and highlight linkages between indicators; and outline the current limitations and key challenges for their future development.

Part I of the study, *Agriculture in the broader economic, social and environmental context*, outlines a set of *contextual indicators* which reveal the influence on agri-environmental relationships of macro-economic forces, the viability of rural areas, biophysical processes, land use changes, and farm financial resources, including farm income and public and private expenditure on agri-environmental schemes. **Part II**, *Farm management and the environment*, examines different farming practices and systems and their impact on the environment, covering *whole farm management, organic farming*, as well as *nutrient, pest, soil* and *irrigation management* practices. **Part III**, *Use of farm inputs and natural resources*, tracks trends in farm input use, including *nutrients, pesticides* (including risks), and *water use*. **Part IV,** Environmental impacts of agriculture, monitors the extent of agriculture's impact on the environment including: *soil quality, water quality, land conservation, greenhouse gases, biodiversity, wildlife habitats* and *landscape*. Explanatory notes and sources to the figures in the *Executive Summary* are provided at the end of the text.

The study is the result of work carried out by the OECD Joint Working Party of the Committee for Agriculture and the Environment Policy Committee. These committees approved the study in August 2000, and agreed that it be published under the responsibility of the OECD Secretary-General. It is primarily aimed at policy makers and the wider public, in both OECD and non-OECD countries. Volume 1, *Concepts and Frameworks*, was released in 1997. Volume 2, *Issues and Design* was published in 1999 and provides the results of the OECD York Workshop (UK) which examined the design of suitable environmental indicators.

Acknowledgements

This study was prepared by the OECD Policies and Environment Division in the Food, Agriculture and Fisheries Directorate, with the participation of Member countries, especially through a questionnaire in 1999 which provided much of the data in the study. OECD wishes to acknowledge the many experts outside the Secretariat who have helped in preparing and editing draft chapters of the study, in particular, Richard Arnold, Ben Ten Brink, Frank Clearfield, Robert Koroluk, Jonathan Lloyd, Eiko Lubbe, Katsuyuki Minami, Jamie Morrison, Andrew Moxey, Leslie Russell, Jesper Schou, Nicola Shadbolt, Dirk Wascher, Daniel Zürcher and also Richard Pearce for editing the complete text. The following Secretariat staff, under the overall guidance of Wilfrid Legg, contributed to drafting this study: Kevin Parris, Yukio Yokoi, Outi Honkatukia, Seiichi Yokoi, Gérard Bonnis, Morvarid Bagherzadeh, Jeanne Richards, Dan Biller and Myriam Linster, and many other OECD staff who provided comments on the study. Technical assistance was provided by Françoise Bénicourt, Theresa Poincet, Laetitia Reille, and Véronique de Saint-Martin, with the production and marketing of the publication provided by Mubeccel Valtat-Gevher, Colette Goldstein and Catherine Candea and their colleagues.

HIGHLIGHTS

The impacts of agriculture on the environment are of major public concern, in the context of agricultural policy reform, trade liberalisation, international environmental agreements and the achievement of sustainable agriculture. Monitoring the environmental performance of agriculture and assessing the environmental effects of policies requires information on agri-environmental interactions.

This Report is a stocktaking of results in measuring the environmental performance of agriculture to address a range of agri-environmental areas considered of policy relevance to OECD member countries. The Report is primarily aimed at policy makers, other stakeholders and the wider public, including non-member OECD countries, interested in recent developments and trends in agri-environmental performance.

An improved capacity to assess agriculture's environmental performance has been a key outcome of the Report. This has been achieved by building on Member countries' experiences and earlier OECD work, and through helping to: establish a common framework, harmonised methodologies and data sets to calculate indicators; advance knowledge of agri-environmental interactions and linkages; and foster an exchange of national and international approaches and experiences in developing indicators.

Some positive developments can be observed. There has been a decrease of over 10 per cent in both nitrogen and pesticide use in many *European* countries and *Japan*, and associated improvements in water quality and lowering of greenhouse gas emissions, since the mid-1980s. Soil erosion rates have declined in *Australia*, *Canada*, and the *United States*, and progress has been made in adopting farming practices that enhance environmental performance, such as the shift to using nitrogen management plans, integrated pest management and conservation soil tillage.

The environmental performance of agriculture has deteriorated in some cases. This has been associated with the intensification of farm production in some areas and the regional concentration of activities, such as livestock farming. In turn, this has resulted in higher levels of nutrient surpluses, ammonia and greenhouse gas emissions, with consequent increases in water and air pollution, such as in regions of *Canada*, *Europe*, *New Zealand* and the *United States*. There is also growing competition for scarce water resources both between agriculture and other users and also meeting the water needs of aquatic ecosystems for recreational and environmental purposes, particularly in the drier regions of *Australia*, the *United States* and *Southern Europe*.

Overall agri-environmental indicator results over the last 10-15 years have been mixed. The overall indicator results suggest that for many agri-environmental issues, and regions within OECD countries, pollution levels are relatively high (*e.g.* nitrogen and pesticide loadings in water) and that various environmental risks persist (*e.g.* soil erosion, water resource depletion). Agriculture, however, does provide certain environmental benefits and services (*e.g.* providing wildlife habitat, acting as a sink for greenhouse gases, providing landscape amenity).

Interpreting the overall impact of agri-environmental trends can be complex. For example, the increase in agricultural production and total environmental emission levels has been offset, to some extent, by improvements in farm input and natural resource use efficiency. This is the case with the use of fertilisers, pesticides, and water in some countries, where improvements in technology and farm management practices have led to a reduction in the use of these inputs per unit volume of production.

Changes in the environmental performance of agriculture can be attributed to a wide range of factors. These include variations in agricultural production, structural and technological developments, the influence of public pressure and market forces on farming practices and systems, and changes in policy settings and priorities. The linkages between indicators observed in this Report suggest a sequence of causes and effects. Changes in market conditions or policy settings affect the level of financial resources available to farmers, which influence production decisions and farm practices, while agri-environmental measures and environmental regulations may constrain actions taken by farmers. This leads to different environmental outcomes depending on varying agro-ecological conditions.

These results need to be seen in a broader context. For most OECD countries agriculture's role in the national economy is small, but in terms of the use of natural resources is significant, accounting for around 40 per cent of total land use and 45 per cent of water use. Where agricultural production has increased by around 15 per cent, resulting mainly from improvements in productivity with capital replacing labour helped by new technologies. The higher production has been achieved from increasing yields as the total agricultural land area has decreased, by 1 per cent, and the use of water has risen, by over 5 per cent. Agricultural employment has declined by about 8 per cent, while the farm population has aged. Farm numbers have declined with a corresponding increase in farm size.

OECD agriculture continues to be characterised by high support, which currently accounts for about 36 per cent of total farm receipts, although there are wide variations in the level, composition and trends in support among countries and commodities. Where agricultural and trade policies have caused distortions in market input and output price signals, in some cases this has led to environmental damage. Policy reform should help improve agriculture's environmental performance but in some cases could reduce environmental benefits. As part of the reform process and in response to public pressure, many countries have introduced agri-environmental and environmental measures to help achieve environmental goals.

For some agri-environmental areas there is incomplete knowledge and data to establish trends. Information is incomplete, for example, concerning the degree of groundwater pollution or rate of depletion resulting from agricultural activities, and the human health and environmental risks associated with the use of pesticides. In other cases the linkages between different indicators are understood but are not easy to measure, such as between changes in farm management practices and environmental outcomes, or attributing the relative impact of agriculture and other activities, for example, on water pollution. Also for a number of areas, notably agriculture's impact on biodiversity, habitats and landscape, the understanding and measurement of these impacts is still at a preliminary stage of research, partly because of the high costs associated with monitoring programmes.

The future challenge to developing agri-environmental indicators is to meet the objectives of providing information on the current state and changes in the conditions of the environment in agriculture; and using indicators for policy monitoring, evaluation, and forecasting. This requires improving the analytical soundness and measurability of indicators, especially by overcoming conceptual and data deficiencies, and providing a better interpretation of indicator trends. This could contribute to understanding the linkages between indicators (*e.g.* water use, management and pricing) and to examining the synergies and trade-offs between the economic, social and environmental dimensions of sustainable agriculture. Developing a core set of integrated OECD agri-environmental indicators, complemented as necessary by other indicators, could help to achieve these objectives.

BACKGROUND AND SCOPE OF THE REPORT

1. Objectives

The main objectives of the Report are to:

- review and take stock of progress in developing indicators across OECD countries;
- build on earlier OECD work in establishing standard definitions and methods of calculation;
- provide preliminary results of the state and recent trends of environmental conditions in agriculture across OECD countries;
- interpret indicator trends and highlight linkages between indicators; and,
- outline limitations and the key challenges for the future development of indicators.

2. Developing the indicators

Developing the OECD agri-environmental indicators has involved five steps outlined below (see also the OECD agri-environmental indicator website: *http://www.oecd.org/agr/env/indicators.htm*).

Identifying policy relevant issues which indicators should address

The choice of the agri-environmental issues and indicators, shown in Box 1, has been made by OECD Member countries as the current priority areas to address. This represents a consensus that has emerged among OECD countries, building on their experience in developing indicators for policy purposes, as outlined in the OECD Reports: *Environmental Indicators for Agriculture – Volume 1: Concepts and Framework* (1997) and *Volume 2: Issues and Design* (1999). The choice of indicators, however, is an evolving process depending on changing societal pressures and political choices (see also the OECD agriculture and environment website: *http://www.oecd.org/agr/policy/ag-env*).

Developing a common framework to structure the development of indicators

A common framework is used by OECD to structure the process of developing indicators. The *Driving Force-State-Response (DSR) framework* identifies: *driving force indicators*, focusing on the causes of change in environmental conditions in agriculture, such as changes in farm management practices and the use of farm inputs; *state indicators*, highlighting the effects of agriculture on the environment, for example, impacts on soil, water, and biodiversity; and *response indicators* covering the actions taken to respond to the changes in the state of the environment, such as variations in agri-environmental research expenditure. The DSR models builds on the Pressure-State-Response framework used by OECD to develop its environmental indicators (see OECD, *Towards Sustainable Development Environmental Indicators*, 1998, Paris, and also the OECD environmental indicators website: *http://www.oecd.org/env/indicators/index.htm*).

Establishing indicator definitions and methods of measurement

The indicators measure the relationship between primary agriculture and the environment, thus excluding the agro-food chain (*e.g.* pesticide manufacturing, food processing) and the impact of changes in the environment on agriculture (*e.g.* impact of climate change on agriculture). While they cannot be considered as indicators of "sustainability", many indicators can be useful inputs for illustrating the environmental dimension of sustainable agriculture. Some attention is given to the economic and social dimensions of sustainable agriculture in the context of farm financial resources and rural viability (see also the OECD sustainable development initiative website: *http://www.oecd.org/subject/sustdev*).

Collecting data and calculating indicators

The main basis for the data sources and indicator calculations shown in the Report are derived from OECD Member country responses to a *Agri-environmental Indicator Questionnaire* in 1999. The

Box 1. Complete list of OECD Agri-environmental Indicators[1]

I. AGRICULTURE IN THE BROADER ECONOMIC, SOCIAL AND ENVIRONMENTAL CONTEXT		
1. Contextual information and indicators		2. Farm financial resources
• *Agricultural GDP* • *Agricultural output* • *Farm employment* • *Farmer age/gender distribution* • *Farmer education* • *Number of farms* • *Agricultural support*	• *Land use* – Stock of agricultural land – Change in agricultural land – Agricultural land use	• *Farm income* • *Agri-environmental expenditure* – Public and private agri-environmental expenditure – Expenditure on agri-environmental research
II. FARM MANAGEMENT AND THE ENVIRONMENT		
1. Farm management		
• *Whole farm management* – Environmental whole farm management plans – Organic farming	• *Nutrient management* – Nutrient management plans – Soil tests • *Pest management* – Use of non-chemical pest control methods – Use of integrated pest management	• *Soil and land management* – Soil cover – Land management practices • *Irrigation and water management* – Irrigation technology
III. USE OF FARM INPUTS AND NATURAL RESOURCES		
1. Nutrient use	2. Pesticide use and risks	3. Water use
• *Nitrogen balance* • *Nitrogen efficiency*	• *Pesticide use* • *Pesticide risk*	• *Water use intensity* • *Water use efficiency* – Water use technical efficiency – Water use economic efficiency • *Water stress*
IV. ENVIRONMENTAL IMPACTS OF AGRICULTURE		
1. Soil quality	3. Land conservation	4. Greenhouse gases
• *Risk of soil erosion by water* • *Risk of soil erosion by wind* 2. Water quality • *Water quality risk indicator* • *Water quality state indicator*	• *Water retaining capacity* • *Off-farm sediment flow (soil retaining capacity)*	• *Gross agricultural greenhouse gas emissions*
5. Biodiversity	6. Wildlife habitats	7. Landscape
• *Genetic diversity* • *Species diversity* – Wild species – Non-native species • *Eco-system diversity* (see Wildlife Habitats)	• *Intensively-farmed agricultural habitats* • *Semi-natural agricultural habitats* • *Uncultivated natural habitats* • *Habitat matrix*	• *Structure of landscapes* – Environmental features and land use patterns – Man-made objects (cultural features) • *Landscape management* • *Landscape costs and benefits*

1. This list includes all the agri-environmental indicators covered in the Report. For a detailed description of each indicator, see Main Report.
Source: OECD Secretariat.

Questionnaire provided information on the basic data and related indicators currently available or being developed in countries. However, the coverage and quality of responses varied, because certain areas are of little relevance to some countries and the systematic collection of basic data and construction of indicators has only begun recently in many countries. The Report has also drawn on OECD work on environmental data (see OECD, *Environmental Data Compendium 1999*, Paris), and the OECD Working Group on Pesticides development of pesticide risk indicators (see the OECD Working Group on Pesticides website: *http://www.oecd.org/ehs/pest_rr.htm*). Also information and data has been obtained from external sources, such as FAO.

Interpreting indicators trends

The indicators should be viewed as an integrated preliminary set, with caution needed in interpreting trends in individual indicators, for a number of reasons discussed below.

- *Definitions and methodologies for calculating of indicators* are standardised in most cases (*e.g.* the nitrogen use balance definition), but not all (*e.g.* definitions of organic agriculture vary). Also, calculating the indicators are at different stages of development, with work on some areas having a longer background of research, such as nutrient use and soil quality, while for other areas, such as biodiversity, wildlife habitats and landscape, work is at a very early stage.

- *Data quality and comparability* have been expressed as far as possible in terms of the consistency, coherence and harmonisation of data across different indicators, but deficiencies remain such as the absence of data series, variability in data coverage and questions related to data sources.

- *Spatial aggregation* of indicators is at the national level. Because national averages can mask significant variations at the regional level, where possible the Report highlights the possibility of developing regionally disaggregated indicators.

- *Trends and ranges in indicators* are important for comparative purposes across countries rather than absolute levels for many indicators, especially as local, site specific conditions vary considerably within and across countries. Absolute levels, however, are significant where they are above clearly defined scientific limits (*e.g.* nitrates in water).

- *Contribution of agriculture to specific environmental impacts* is sometimes difficult to isolate, especially for issues such as water quality, where the impact of other economic activities is significant (*e.g.* industry) or the natural state of the environment itself contributes to pollutant loadings (*e.g.* the water may contain high levels of naturally occurring salts).

- *Direction of change of the indicators* is unambiguous in terms of the impact on the environment of an increase or decrease in the specific indicator (*e.g.* changes in agricultural greenhouse gas emissions). However, for some indicators it is not always clear what constitutes an environmental improvement or deterioration (*e.g.* changes in landscape indicators).

- *Baselines, threshold levels and targets for indicators* are not used to assess indicator trends in the Report, but some explanation is provided especially where changes diverge significantly from overall OECD average trends.

Many of the limitations of interpreting agri-environmental indicators apply to other indicators. For example, there can be wide variations around national averages of socio-economic indicators (*e.g.* employment), and methodological and data deficiency problems are also not uncommon (*e.g.* wealth distribution). Also work on agri-environmental indicators began quite recently compared with the much longer history of developing economic indicators, such as gross domestic product. Capturing the interface between the biophysical environment and human activities through indicators, is also often more complex than monitoring trends in socio-economic phenomena, while some agri-environmental outputs and effects are also not valued in markets and are not easily measured in physical terms (*e.g.* landscape).

Part I

AGRICULTURE IN THE BROADER ECONOMIC, SOCIAL AND ENVIRONMENTAL CONTEXT

1. **CONTEXTUAL INFORMATION AND INDICATORS**
2. **FARM FINANCIAL RESOURCES**

1. CONTEXTUAL INFORMATION AND INDICATORS

To set the discussion on agri-environmental indicators in this Report in a broader economic, social and environmental context, this Chapter examines the impact on agri-environmental relationships of economic forces, societal preferences, environmental processes, and land use changes.

Economic forces shape the performance of the agricultural sector and its role in the national economy. *Agriculture's contribution to gross domestic product* is under 4 per cent for most OECD countries, with the role of agriculture in the economy declining in all countries during the last decade. The real *value of agricultural output* has risen for most countries over the past 10 years attributed to higher production, the latter almost entirely due to increases in productivity.

Nevertheless, over a 30-year period the value of output has declined, mainly because of a decrease in real commodity prices. Trends in *real net farm incomes* from agricultural activities have been variable over the last 10 years, rising for many countries but sharply declining over recent years in some cases, largely reflecting changes in macro-economic conditions, farm costs and support levels.

The growing world *demand for food and industrial crops* will continue to present a challenge to world agricultural production, especially as some of the future demand will continue to be met by OECD cereal and livestock product exporters. But the future expansion in production may heighten the pressure on the environment through intensification and growth in farm output, particularly for exporting countries.

Agricultural employment as a share of total employment is now less than 7 per cent for most OECD countries, and the *age distribution* of farmers often shows a major share to be over 55 years old. There are very few countries where the majority of new entrants into agriculture are less than 35 years old. A younger, well-educated workforce is more likely to be able to respond rapidly to changing economic and environmental conditions. In addition, there are only a small number of countries where more than 40 per cent of farmers receive even basic agricultural training.

Farm numbers have declined in most OECD countries with a corresponding increase in *farm size*, leading to the concentration of production in a small number of larger farms. The share of small farms in total farm numbers is, at the same time, increasing. Research suggests that the trend toward increasing farm size usually entails field consolidation with the loss of boundary features, as well as intensification as capital replaces labour and the use of inputs per hectare increases.

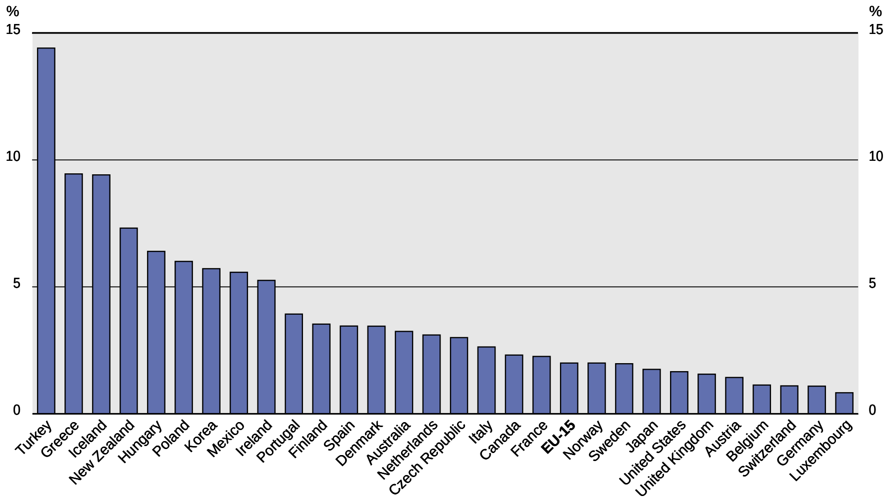
Changes in farm structures have been influenced by t*echnological developments*, some of which have damaged the environment, such as the use of certain pesticides. An increasing focus in research of new technologies relates to *eco-efficiency and environmentally cleaner technologies*, which can increase profitability and reduce environmental harm, for example precision farming.

Agricultural and trade policies in many cases have caused environmental harm by distorting price signals through, for example, linking support to agricultural commodities and encouraging farming on environmentally fragile land, and lowering the costs of inputs, such as energy and water. Support to OECD agriculture is high, but with wide variations in the level, composition and trends among countries and commodities. OECD average share of support to producers in total gross farm receipts, the percentage producer support estimate (PSE), has declined from 40 to 36 per cent between 1986-88 to 1997-99.

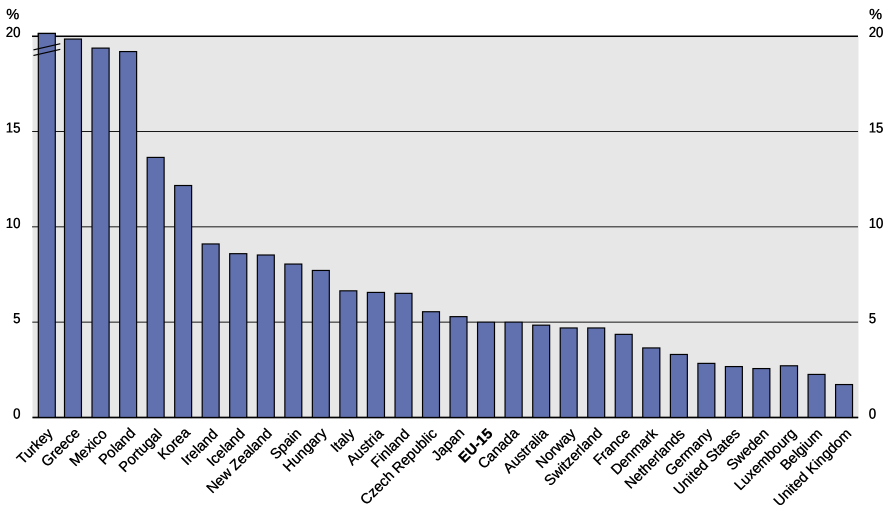
The reform of agricultural policies should improve the allocation of resources and reduce the negative impacts of agriculture on the environment, but reform can also lower performance where agriculture is providing environmental benefits. As part of the reform process OECD countries have introduced *measures to address environmental issues*, mainly focusing on altering farm management practices and land use patterns incompatible with achieving environmental goals.

There is at present insufficient information to provide a full assessment of these changes, but while some improvements have been made, they have been more costly than would have been the case without production enhancing policies. Also, the negative environmental impacts resulting from farming still remain at relatively high levels in many cases.

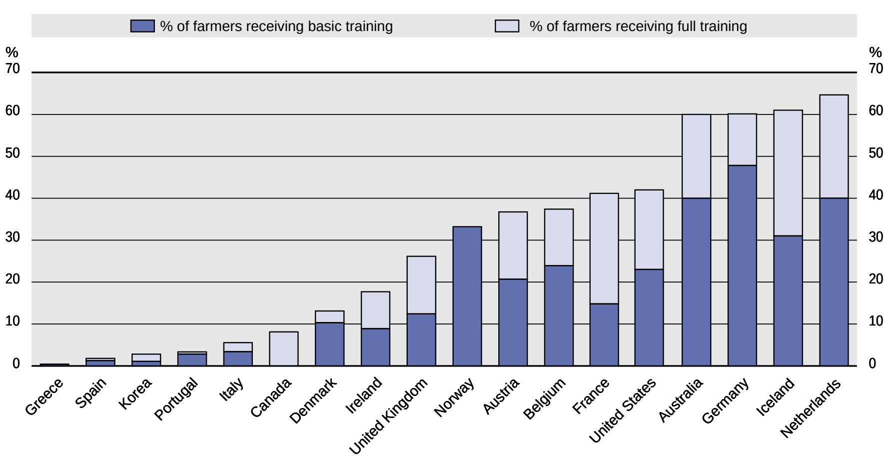
Share of agriculture in Gross Domestic Product: mid-1990s



Share of agricultural employment in total civilian employment: late 1990s



Educational level of farmers: mid/late 1990s



Societal preferences affect agriculture and the environment across a range of issues. There is *growing public concern about agriculture's impact on the environment* in terms of reducing pollution and enhancing benefits, mainly in response to rising incomes, increasing leisure time, heightened public knowledge of these issues, and the desire for the space offered by rural areas.

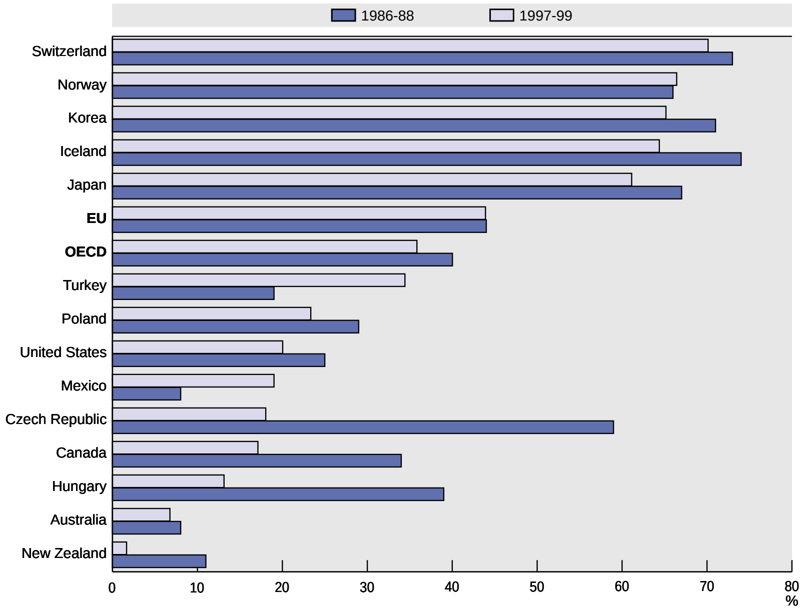
Rural viability relates to issues such as farmer age structures, educational and managerial skills, and access to key services. The retention of a skilled workforce in rural areas and having an appropriate rural community infrastructure, will affect the capacity of farming to adjust and manage their enterprises to changing economic and environmental conditions and the sustainability of agriculture.

Environmental processes relate to the interaction between agriculture and natural environmental processes. Particularly relevant in this respect, is that farming forms a part of the ecosystem rather than being external to it, unlike most other economic activities. Agri-environmental relationships are often complex, site specific and non-linear, with a wide range of biophysical conditions within and across OECD countries, reflecting, for example, variations in climate, soils, availability of water resources, and land use patterns.

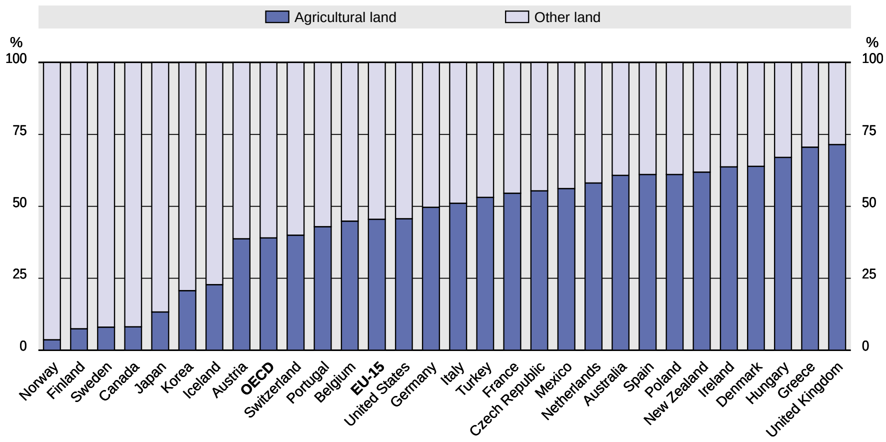
Land use changes represent the integrating element between the economic, societal and environmental influences on agriculture. For most OECD countries *agricultural land* occupies over 50 per cent of the total land area, with only a small reduction in area over the past 10 years, mainly through agricultural land being converted to forests in marginal farming areas. The change of *marginal farming land* to other land uses has raised concerns related to the associated harmful environmental and socio-economic impacts in some countries, but equally the conversion of this land may enhance its biodiversity and related amenity values.

The *pattern of agricultural land use* change within countries has mainly involved a growing share of permanent pasture in agricultural land, largely because of the adoption of land diversion schemes. Changes in farm land use from arable crops to pasture, more to less intensive cropping systems, and in terms of different cropping patterns can have major environmental effects, such as through altering soil erosion rates.

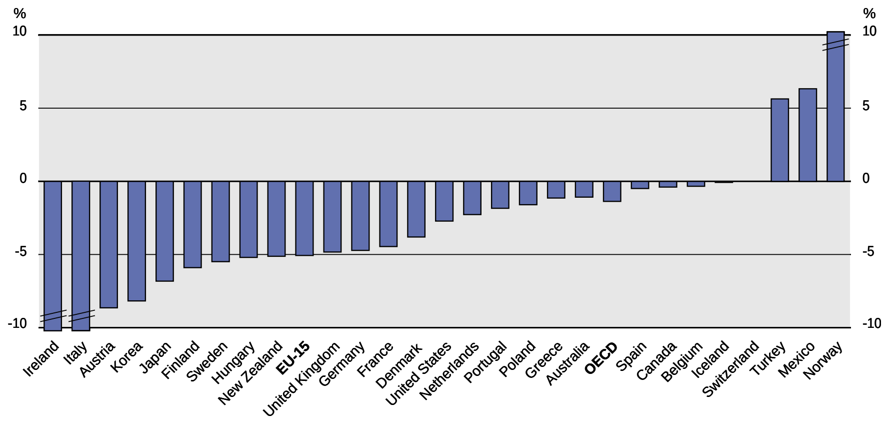
Percentage Producer Support Estimate: 1986-88 to 1997-99



Share of agricultural land use in the total national land area: 1995-97



Change in the agricultural land area: 1985-87 to 1995-97



2. FARM FINANCIAL RESOURCES

Context

Financial resources are a key driving force behind farmers' actions, but are not directly related to environmental performance. The relationship between farm financial resources and environmental outcomes is complex, as farms can remain profitable at the expense of environmental degradation, at least over the medium term. Profitable farms, however, can better afford to take the environment into account in their investment and farm management decisions.

The availability of financial resources influences farming practices; the ability to acquire new technologies; as well as the type, level and intensity of input use and of production. They also affect the degree of adoption of environmentally benign production methods, including farmers' attitude towards environmental risks; rates of structural adjustment, including farm amalgamation; and the exit and entry of farmers into the sector.

The two main sources of farm financial resources in OECD countries include returns from the market and government support (farm household income can also include non-farm sources of income). The type and level of support provided to farmers varies widely across the OECD. Since the late 1980s many countries have introduced agri-environmental measures, and land diversion schemes with environmental objectives, mainly aimed at: changing farming practices (*e.g.* raising environmental awareness through farm advisory services or voluntary farm groups); developing agri-environmental research (*e.g.* on soil carbon changes); providing payments to farmers for reducing environmental damage (*e.g.* animal waste treatment facilities) and enhancing environmental services (*e.g.* laying hedgerows). In addition, farmers also have to comply with environmental standards and regulations, especially with regard to the use of pesticides and inorganic fertilisers.

Indicators and recent trends

OECD indicators on farm financial resources reflect the financial health of the farm and cover two areas: first, net farm income from agricultural activities, and second, public and private agri-environmental expenditure, including agri-environmental research expenditure.

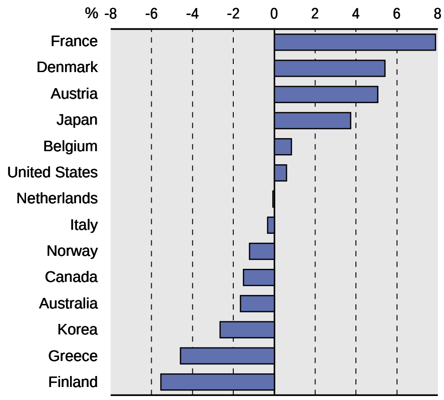
Net farm income is calculated as the difference between gross output and all expenses, including depreciation at the farm level. While nominal net farm incomes have risen for most OECD countries over the past 10 years, the performance in real terms has been variable and over recent years net farm incomes have sharply declined for some countries. Agricultural households also obtain a substantial share of their income from non-agricultural activities in many countries, and in some countries the total average income of agricultural households exceeds that of non-agricultural ones.

Public and private agri-environmental expenditure is aimed at both mitigating the negative impacts of agriculture on the environment and also enhancing the benefits. For a large number of OECD countries there has been a very rapid increase in public agri-environmental expenditure over the 1990s, associated with the introduction of many new environmental measures related to agriculture. The use of this expenditure varies widely across countries, reflecting differences in agri-environmental concerns and priorities.

A significant share of *public agricultural research expenditure* in many countries is spent on addressing agri-environmental concerns, and in some cases this share has been increasing since the mid-1980s. While in a few countries *private agri-environmental expenditure* is important, there is little systematic collection of this expenditure data.

Nominal and real net farm income from agricultural activities: mid-1980s to mid-1990s

Annual change in real net farm income

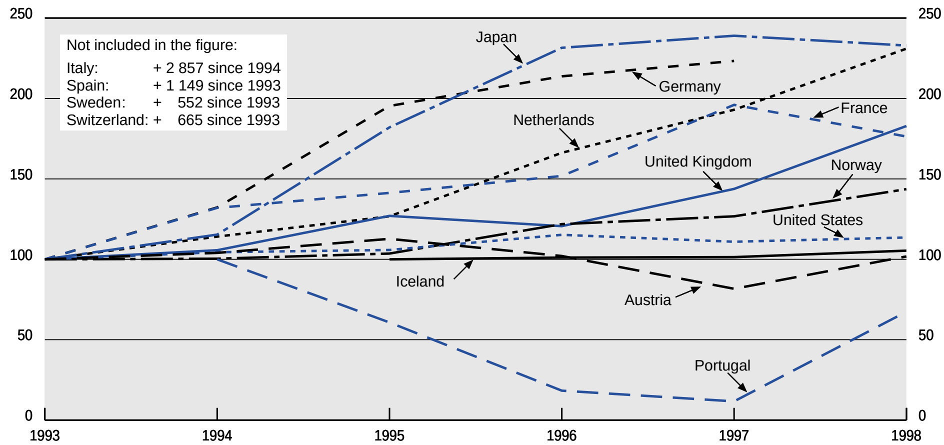


Percentage annual change in net farm income

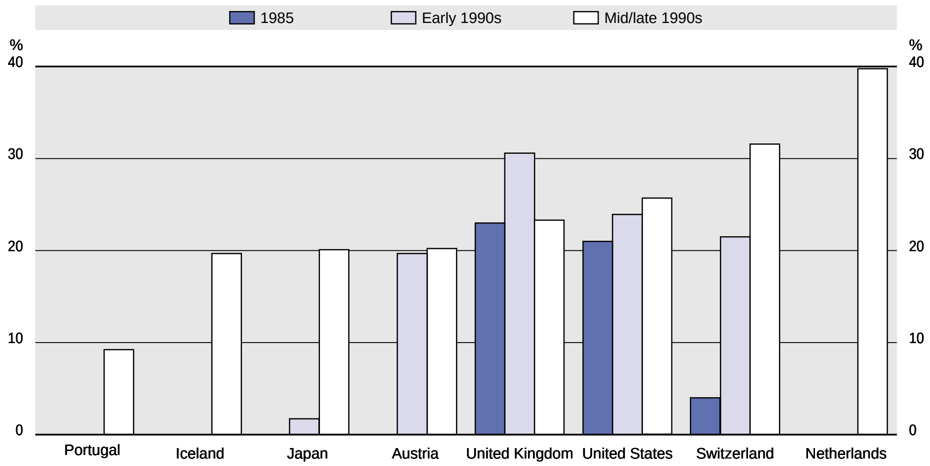
	Period	Nominal income	Real income
France	1990-1995	10.3	7.9
Denmark	1985-1997	7.8	5.4
Austria	1985-1997	7.4	5.1
Japan	1985-1998	4.9	3.7
Belgium	1987-1994	2.9	0.8
United States	1991-1998	2.5	0.6
Netherlands	1988-1994	0.5	-0.1
Italy	1987-1995	4.5	-0.3
Norway	1985-1997	1.8	-1.2
Canada	1985-1997	1.2	-1.5
Australia	1988-1996	1.2	-1.6
Korea	1990-1998	1.2	-2.6
Greece	1986-1995	8.2	-4.6
Finland	1991-1996	-4.1	-5.6

Public expenditure on agri-environmental goods, services and conservation : 1993 to 1998

Index 1993 = 100



Share of public agri-environmental research expenditure in total agricultural research expenditure: 1985 to mid/late 1990s



Part II

FARM MANAGEMENT AND THE ENVIRONMENT

1. FARM MANAGEMENT

1. FARM MANAGEMENT

Context

Environmental conditions and farming systems vary within and across OECD countries and, consequently, best farm management practices vary from one region to another. Farm management decisions are influenced by environmental regulations, agricultural support measures, investments in research, education and extension services and site-specific environmental conditions. Information on farm management practices, and how these practices affect the environment and meet compulsory, regulatory or voluntary standards, is an important tool for policy makers.

There can be trade-offs in implementing environmentally sound management practices. Reducing soil erosion, for example, whereby farmers move from conventional to reduced or no-tillage in crop production, can be achieved if weeds are controlled with herbicides. An environmental side-effect of these practices is a likely change in water movement in the soil, with no-tillage leading to increasing infiltration and percolation of nutrients such as nitrate to the water table compared with conventional tillage. In addition, the increase in herbicide use may cause pesticide leaching. Thus, the objective of lowering soil erosion through no-tillage may lead to some negative environmental effects.

Indicators and recent trends

Farm management indicators have the potential to help policy makers take into account the linkages and trade-offs between different management practices and their impact on the environment, including: whole farm management involving the overall farming system; and farm management aimed at specific practices related to nutrients, pests, soils, and irrigation.

Concerning *whole farm management indicators*, the share of farms with environmental *whole farm plans* is increasing, but cross-country data is limited. Also the share of agricultural area under *organic farming* has increased significantly over the past ten years, but from a very low base and with wide variations among OECD countries. Many countries now encourage conversion to and maintenance of organic farming by providing financial compensation to farmers for any losses incurred during conversion.

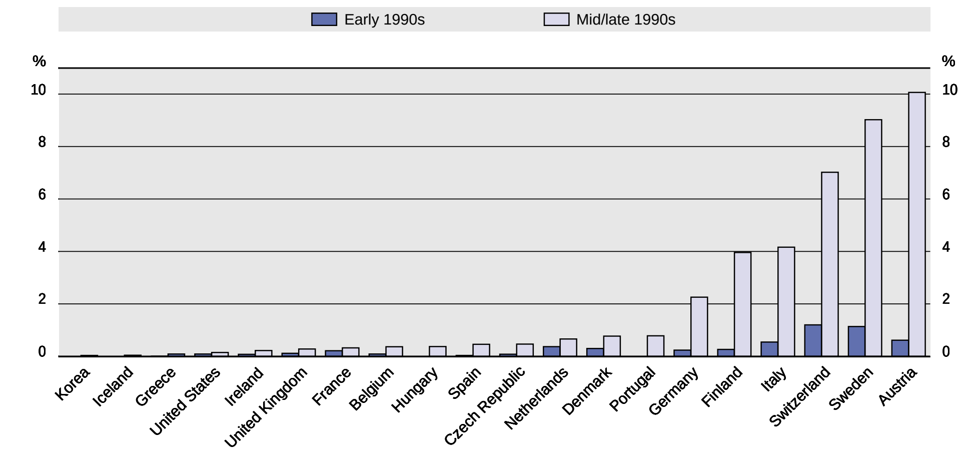
Nutrient management indicators include the share of farms with nutrient management plans and the frequency of soil nutrient tests. Although many countries have developed nutrient management plans, there is little quantitative information available, however, and soil tests are conducted in most OECD countries at regular intervals.

Pest management indicators measure the share of cultivated agricultural area that is not treated with pesticides and the share of cultivated agricultural area under integrated pest management. Based on limited information, for a few countries it appears both practices have been used more widely during the 1990s.

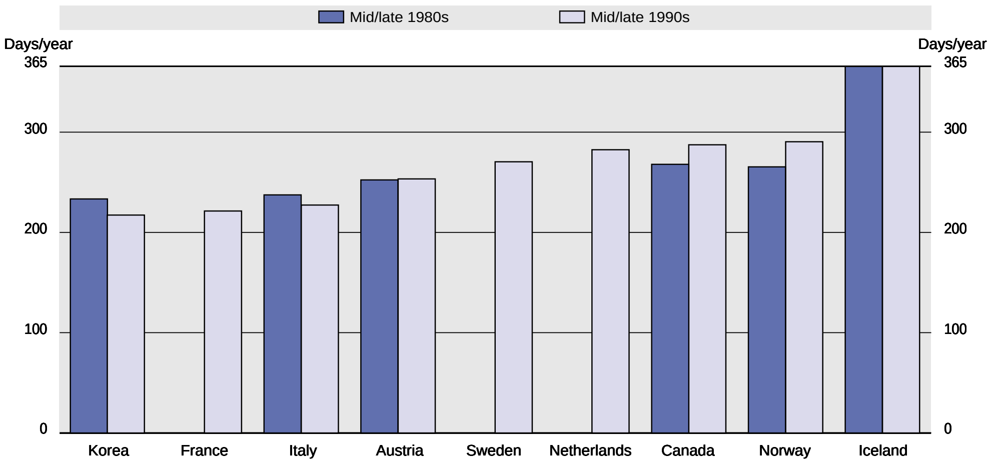
Soil and land management indicators measure the number of days in a year that the soil is covered with vegetation. The greater the cumulative soil cover, the greater the protection from soil erosion, compaction and run-off and the contribution, in general, to biodiversity. Many OECD countries have policy initiatives to increase soil cover and promote environmental land management practices. In a number of countries, soil cover days have increased since the mid-1980s and now exceed 250 days per year, but in a few countries days of soil cover has decreased.

Irrigation and water management indicators measure the share of irrigation water applied by different irrigation technologies, from the least efficient methods (*e.g.* flooding) to technologies (*e.g.* drip-emitters) that use water more efficiently. For the few countries where information on changes in irrigation technologies exist, this suggests a shift toward technologies that use water more efficiently. Moreover, water is not considered a scarce resource in many OECD countries and consequently issues related to irrigation efficiency are of less importance in those countries.

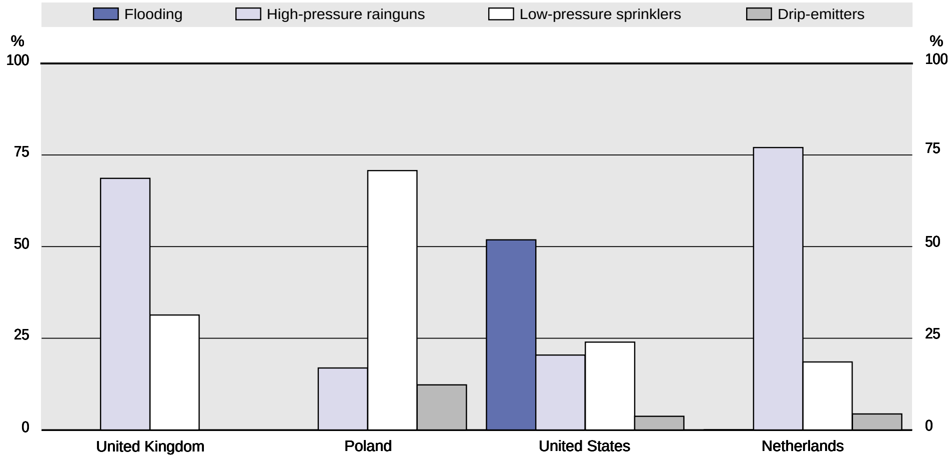
Share of the total agricultural area under organic farming: early 1990s and mid/late 1990s



Number of days in a year that agricultural soils are covered with vegetation: mid/late 1980s and mid/late 1990s



Share of total irrigated crop area using different irrigation systems: mid/late 1990s



Part III

USE OF FARM INPUTS AND NATURAL RESOURCES

1. **NUTRIENT USE**
2. **PESTICIDE USE AND RISKS**
3. **WATER USE**

1. NUTRIENT USE

Context

Inputs of nutrients, such as nitrogen and phosphorus, are essential to agricultural production, and integral to raising productivity. At the same time, a surplus of nutrients in excess of immediate crop needs can be a source of potential environmental damage to surface and ground water (eutrophication), air quality (acidification) and contribute to global warming (greenhouse effect). If soils are farmed and nutrients not replenished, this can lead to declining soil fertility and may impair agricultural sustainability through"soil mining" of nutrients.

Many OECD countries have established goals to reduce nutrient emissions from agriculture. These are closely linked to the need for agriculture to comply with national standards for nitrate and phosphate emissions into aquatic environments. A number of international conventions and agreements also have the objective of limiting and reducing transboundary emissions into the environment, including nutrient emissions from agriculture into surface and ground water, marine waters and the atmosphere.

Indicators and recent trends

The OECD *soil surface nitrogen balance indicator* measures the difference between the nitrogen available to an agricultural system (inputs, mainly from livestock manure and chemical fertilisers) and the uptake of nitrogen by agriculture (outputs, largely crops and forage). A persistent surplus indicates potential environmental pollution, while a persistent deficit indicates potential agricultural sustainability problems.

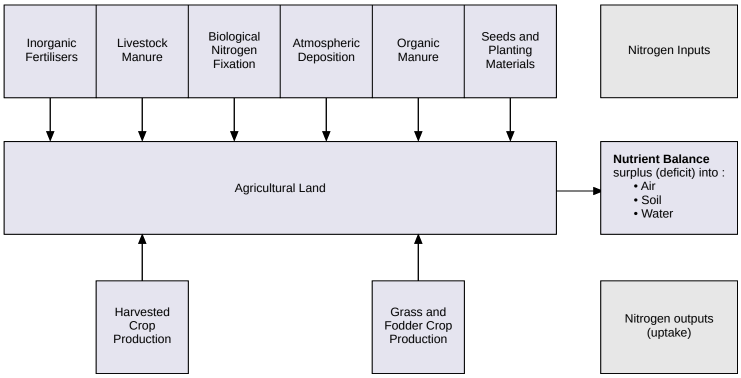
The indicator provides information on the potential loss of nitrogen to the soil, the air, and to surface or groundwater. However, nitrogen loss through the volatilisation of ammonia to the atmosphere from livestock housing and stored manure is excluded from the calculation.

The trend with regard to surpluses in national nitrogen soil surface balances over the last decade is downward or constant for most OECD countries, which suggests that the potential environmental impact from agricultural nitrogen emissions is decreasing or stable. Some countries with a relatively high nitrogen surplus have reported significant reductions, although for a few countries surpluses have risen.

The spatial variation of nitrogen surpluses within a country can be considerable. Regional data suggests that even in countries with a relatively low national nitrogen surplus, nitrate pollution is experienced in some localities, while soil nutrient deficits occur in others.

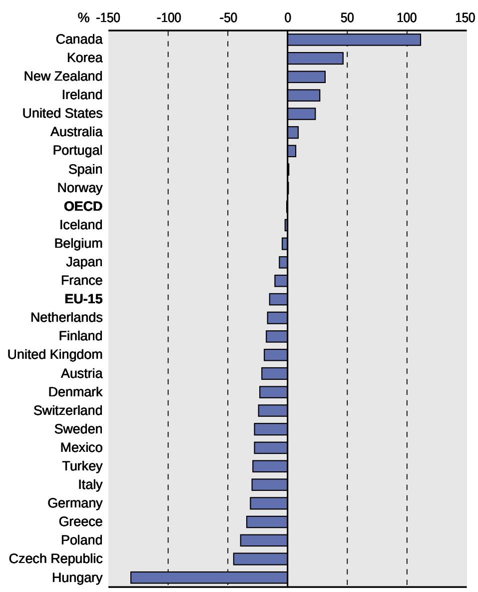
A second nutrient use indicator, the *efficiency of nitrogen use in agriculture*, measures the physical nitrogen input/output ratio. This indicator has shown an improvement in nitrogen use efficiency for most countries over the past decade. However, there is considerable variation across countries in the efficiency of using nitrogen in agriculture, and in some cases the efficiency of nitrogen use has deteriorated.

The main elements in the OECD soil surface nitrogen balance



Soil surface nitrogen balance estimates: 1985-87 to 1995-97

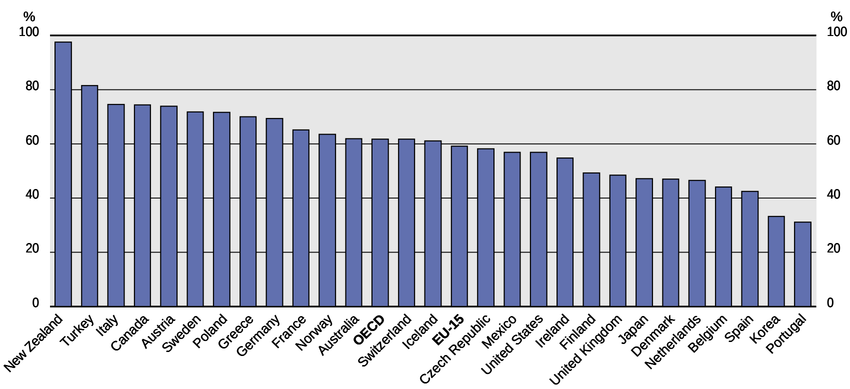
Change in the nitrogen balance
kg/ha of total agricultural land



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
Spain	40	41
Norway	72	73
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
Sweden	47	34
Mexico	28	20
Turkey	17	12
Italy	44	31
Germany	88	61
Greece	58	38
Poland	48	29
Czech Republic	99	54
Hungary	47	-15

Nitrogen efficiency based on the soil surface nitrogen balance: 1995-97
Percentage of nitrogen uptake (output) to nitrogen input



2. PESTICIDE USE AND RISKS

Context

Agricultural pesticides contribute to 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 to a pesticide depends on the way it is applied and its mobility and persistence in the environment.

Pesticide use by farmers depends on a multitude of factors, such as climatic conditions, the composition and variety of crops, pest and disease pressures, farm incomes, pesticide cost/crop price ratios, pesticide policies and management practices. Pesticide indicators are potentially a useful tool to help policy makers monitor and evaluate policies and also provide information concerning human and environmental pesticide risks.

All OECD countries have a regulatory system that assesses pesticides prior to their release for sale, to ensure they do not pose unacceptable risks to the environment and public above nationally agreed thresholds. A number of countries have also set targets to reduce the total quantity of agricultural pesticides used over a given time period. In addition, policies to reduce risk, and other measures like pesticide taxes, are being used in some countries, to reduce the environmental and health impacts of pesticide use.

Indicators and recent trends

OECD is developing two kinds of indicators. One shows pesticide use trends over time based on sales and/or use data in terms of active ingredients. The other indicator tracks trends in pesticide risks by combining information on pesticide hazard and exposure with pesticide use data and information on the conditions that might affect risks. Pesticide use indicators are simpler, but because the policies of OECD member countries aim ultimately to reduce risks, it is important to develop the more complex but highly policy relevant indicators of risk trends.

Overall the trend in pesticide use over the last decade has remained constant or declined in most OECD countries, although for a few countries use has increased. The reduction can be explained partly by changing crop prices, greater efficiency of pesticide use as a result of improvements in pest management practices and technology, and government policies aimed at both improving pest management practices, and in some cases targeting a reduction in pesticide use.

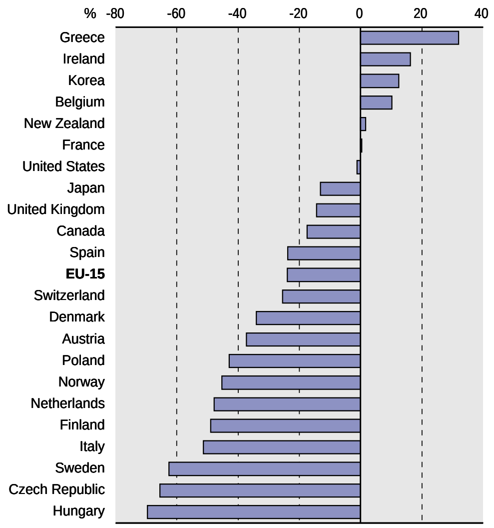
There is evidence to suggest an increasing efficiency in the use of pesticides for some OECD countries, with the volume of crop production over the past 10-12 years increasing more rapidly than pesticide use. For a considerable number of countries, however, annual changes in pesticides use appear to be closely correlated with fluctuations in annual crop production trends.

The close correlation between trends in pesticide use and risks estimated by a few OECD countries, over a period of 10 or more years suggest that pesticide risks to human health and the environment can be reduced by reducing the use of particular chemicals. Caution is required, however, in linking trends in pesticide use with changes in risks. This is because a change in pesticide use is not always equivalent to a change in risks, especially with the development of more targeted pesticides, and because different pesticides pose different types and levels of risks.

Preliminary results of OECD work on pesticide risk indicators for the aquatic environment show that different indicator methods can produce different pesticide risk trends, even when using the same data on pesticide risks and use.

Pesticide use in agriculture: 1985-87 to 1995-97

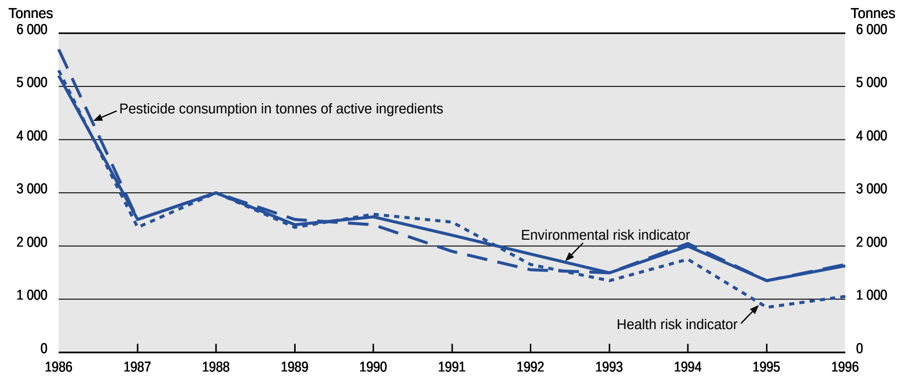
Change in tonnes of active ingredients



Tonnes of active ingredients

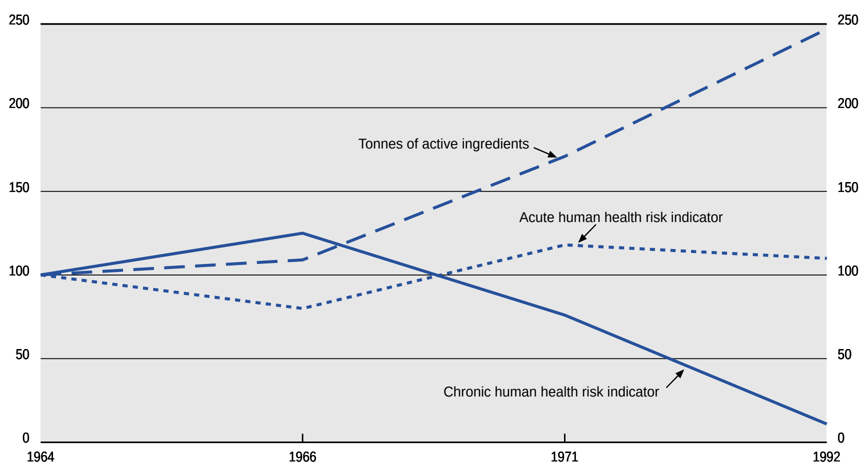
	1985-87	1995-97
Greece	6 928	9 143
Ireland	1 812	2 107
Korea	22 276	25 063
Belgium	8 806	9 710
New Zealand	3 690	3 752
France	96 897	97 229
United States	377 577	373 115
Japan	97 672	84 850
United Kingdom	40 768	34 910
Canada	35 370	29 206
Spain	41 592	31 704
EU-15	333 804	253 684
Switzerland	2 456	1 832
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

Comparison of the environmental and health risk indicators with the quantity of pesticides sold: Sweden, 1986 to 1996



Indicators of pesticide use and human health risks: United States, 1964 to 1992

Index 1964 = 100



3. WATER USE

Context

In some regions in OECD countries agriculture is facing increasing competition for surface and groundwater from urban and industrial demands. Also there is a growing recognition to meet environmental needs through allocations of water for the environment and protection of down-stream impacts from agricultural pollution. Even so, for some OECD countries the issue of water use is not a policy concern because they are richly endowed with water resources.

Governments have traditionally invested in the development of irrigation schemes for the purposes of national and regional development. This often involved a substantial subsidy to establish and maintain irrigation systems and the consequent underpricing of water to agriculture. A number of OECD countries are beginning to seek more efficient and effective use of water in agriculture, by moving towards a full-cost recovery system of water pricing, as a means of adequately valuing water as an input to agricultural production.

Indicators and recent trends

OECD is developing three indicators related to agriculture's use of surface and groundwater: first the intensity of water use by agriculture relative to other users in the national economy; second the measurement of the technical (volume) and economic (value) efficiency of water use on irrigated land; and third a water stress indicator to gauge the extent to which diversions or extractions of water from rivers are impacting on aquatic ecosystems.

The share of agriculture in total national water utilisation is high for most OECD countries, with the sector currently accounting for nearly 45 per cent of total OECD water utilisation, and over 60 per cent for nine OECD countries. While utilisation levels are far below available water resources for most countries, for more arid regions the utilisation intensity of water, especially by agriculture, is a much higher share of available resources. In these situations agriculture has to compete with other users for scarce available water resources.

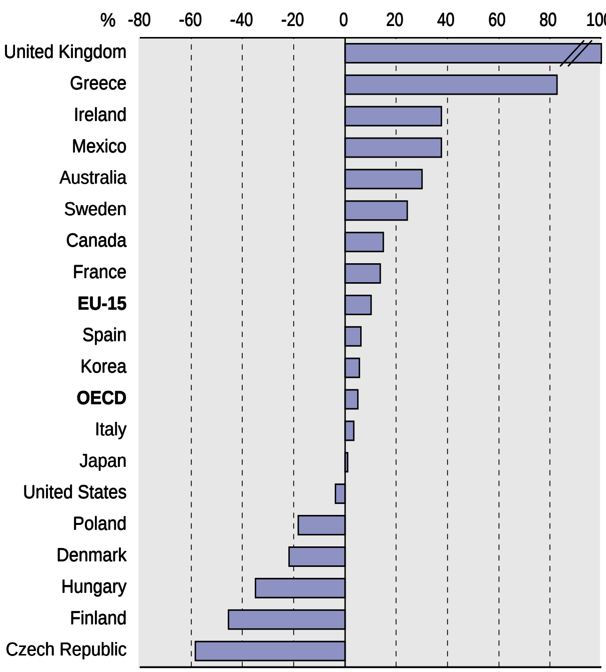
Even where competition for water resources between agriculture and other sectors is less pronounced, the growing need to meet recreational and environmental demands for water may require that agriculture improves its efficiency of water use.

Information on the technical or economic efficiency of irrigation water use across OECD countries is extremely limited. Since the early 1980s there has been a continuous upward trend in water use for irrigation in many OECD countries, associated with the increase in the irrigated land area. The expansion in the irrigated area has been mainly encouraged by government investment in irrigation infrastructure and an irrigation water subsidy. The price of water paid by farmers in many OECD countries is substantially below that paid by industrial and household users, even when differences in water quality and the costs of water conveyancing systems between agriculture and other users are taken into account.

There is relatively little information on the extent or trends in water stress caused by diverting surface water from rivers for agricultural use. Also very few OECD countries define and monitor flow rates for rivers subject to diversion of water for agricultural use. In part, this lack of information highlights for many OECD countries that water stress caused by agricultural diversions from rivers is not a concern. Where flow rates are defined and measured, this is to help allocate inter-provincial river flows or transboundary flows.

Total agricultural water use: early 1980s to mid/late 1990s

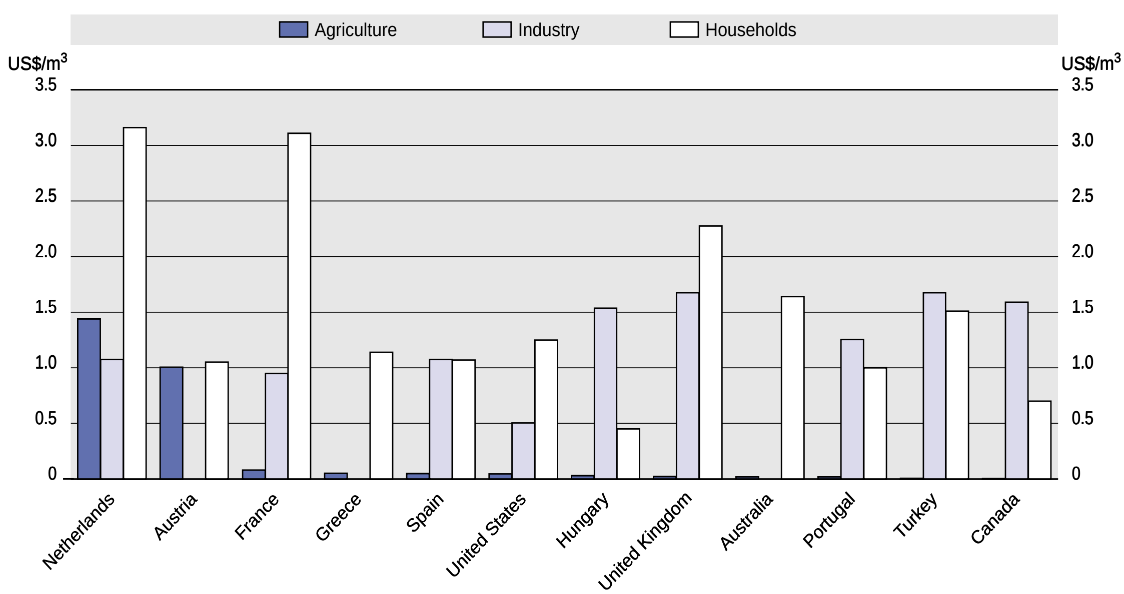
Change in total agricultural water use



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

Comparison of agricultural, industrial, and household water prices: late 1990s



Part IV

ENVIRONMENTAL IMPACTS OF AGRICULTURE

1. **SOIL QUALITY**
2. **WATER QUALITY**
3. **LAND CONSERVATION**
4. **GREENHOUSE GASES**
5. **BIODIVERSITY**
6. **WILDLIFE HABITATS**
7. **LANDSCAPE**

1. SOIL QUALITY

Context

Enhancing soil quality is essential for maintaining agricultural productivity. It can be degraded through three processes: *i)* physical (*e.g.* erosion, compaction); *ii)* chemical (*e.g.* acidification, salinisation); and *iii)* biological degradation (*e.g.* declines in organic matter). These degradation processes are linked to changes in farm management practices, climate and technology. There can be lags between the incidence of degradation, the initial recognition of a problem by farmers and the development of conservation strategies.

Some aspects of soil degradation are only slowly reversible (*e.g.* declines in organic matter) or are irreversible (*e.g.* erosion). Essentially farmers need to balance three key aspects of soil quality: sustaining soil fertility, conserving environmental quality, and protecting plant, animal and human health.

Given the perspective of maintaining soil quality to ensure agricultural productivity, expenditure on soil conservation, both from private and government sources, is frequently a substantial share of total agri-environmental expenditure. Government policies dealing with soil quality improvement commonly provide a range of approaches, including investment and loans to promote conservation practices, and advice on soil management.

Indicators and recent trends

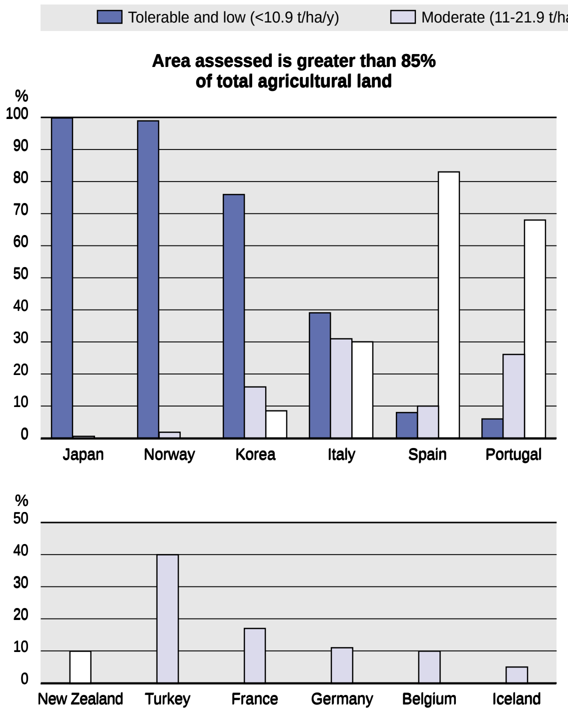
There are two OECD indicators that address on-farm soil quality: *i)* risk of water erosion and *ii)* risk of wind erosion. These are estimates of the share of agricultural land affected at different risk intervals from low/tolerable to high/severe categories. Water and wind erosion indicators are considered to be of highest priority, as other soil degradation processes, such as soil compaction and salinisation are, in general, only of concern in specific regions of OECD countries. Wind erosion is more prevalent in farming regions with major expanses of cultivated open prairies and rangeland.

While the area of agricultural land at high/severe risk to water and wind erosion is not extensive, for certain OECD countries more than 10 per cent of agricultural land fall within this risk class. Trends in water erosion over the past ten years, for a limited number of OECD countries appear to show a reduction from high/moderate classes into tolerable/low classes of water erosion. The reduction in both water and wind erosion largely reflects a combination of the adoption of conservation or no tillage, less intensive crop production and the removal of marginal land from production.

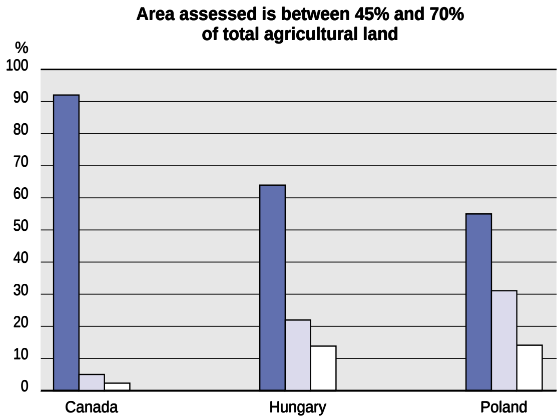
While, in some OECD countries, certain regions are affected to a significant extent by other forms of soil degradation, such as acidification, salinisation, soil compaction and toxic contamination, there is evidence that these problems are beginning to improve in some cases. These improvements are being achieved as a result of government schemes that provide encouragement and advice to farmers to adopt soil conservation practices, such as crop residue management, conservation and land retirement.

There are few estimates of the value of agricultural production foregone as a result of soil degradation, but those available indicate that it might be in excess of 5 per cent of the total annual value of agricultural production in some countries.

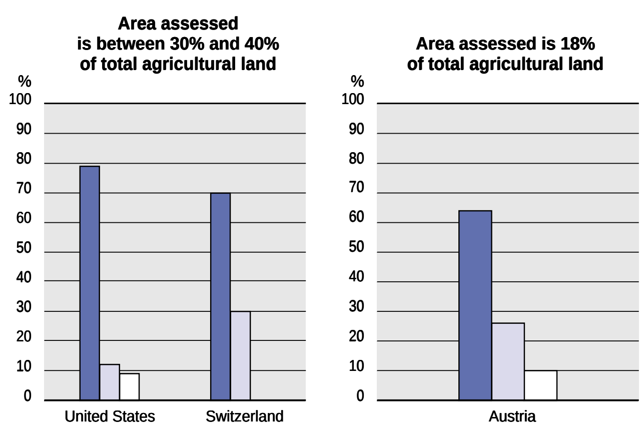
Share of agricultural land area affected by water erosion by area assessed: 1990s



	% 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



	% of agricultural area assessed	Period assessed
Canada	54	1996
Hungary	69	1995-1998
Poland	48	1998



	% of agricultural area assessed	Period assessed
United States	31	1992
Switzerland	37	1985-89
Austria	18	1996

2. WATER QUALITY

Context

The key areas of concern regarding agriculture and water quality are related to nitrate pollution in surface and groundwater; phosphorus levels in surface water; contamination with pesticides; and the harmful effects of soil sediments and mineral salts. An excessive level of agricultural pollutants in water is a human health concern since it impairs drinking water quality, while excessive concentrations of pollutants cause ecological problems including eutrophication.

Indicators and recent trends

Two approaches are being developed by OECD with respect to measuring the impacts of agriculture on water quality. These are "risk" and "state" indicators with emphasis on nitrate and phosphorus. Risk indicators estimate the potential contamination of water originating from agricultural activities. State indicators measure the actual trends in concentrations of pollutants in water against a threshold level, in areas vulnerable to pollution from agriculture. Risk indicators are being used in a number of countries, partly because monitoring the state of water quality can be costly and difficult, especially in terms of distinguishing between the contribution of agriculture and that of other sources of water quality impairment, such as from industry.

Those OECD countries which are establishing risk indicators have helped to provide an indirect measure of the impacts of nitrate and phosphorus losses from agriculture to water. The indicators have been useful in revealing the overall national trends in risk on nutrient contamination, and differences at a regional level, drawing on range of existing data to develop the indicator, including nutrient balances.

While agriculture is not the only sector which burdens aquatic environments with pollutants, in the case of nitrogen and phosphates it is a major contributor in most OECD countries. Recent estimates indicate that, in a considerable number of countries, agriculture accounts for more than 40 per cent of all sources of nitrogen emissions and over 30 per cent of phosphorus emissions into surface water.

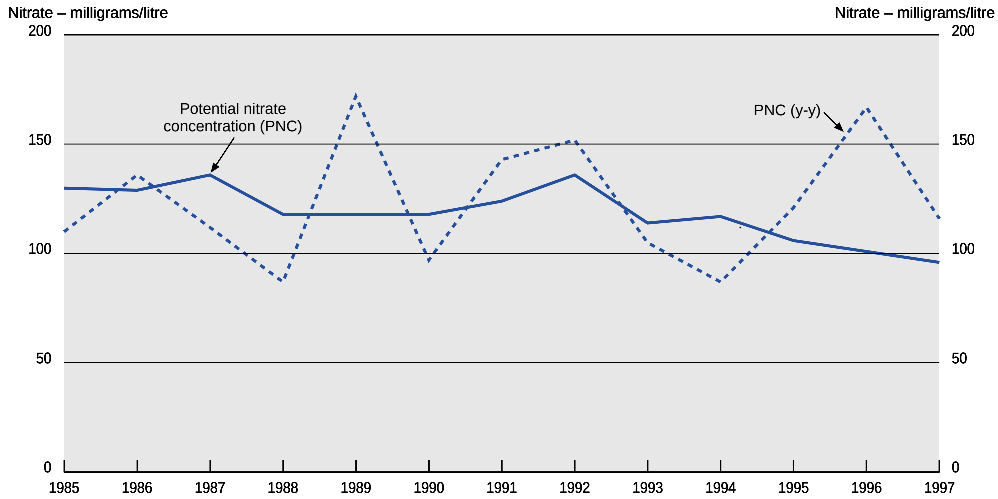
Although the trend in nutrient surplus from agriculture is declining in most OECD countries, the growing contribution of agriculture to the overall level of nutrient contamination of water largely reflects the trend towards the reduction in point sources of nutrient pollution, such as pollution from industry.

The extent of groundwater pollution from agricultural nutrients is less well documented than is the case for surface and marine waters, largely because of the cost involved in sampling groundwater. Moreover, correlating nutrient contamination levels in groundwater with changes in farming practices and production systems is difficult, because it can take many years for nutrients to leach through overlying soils into aquifers.

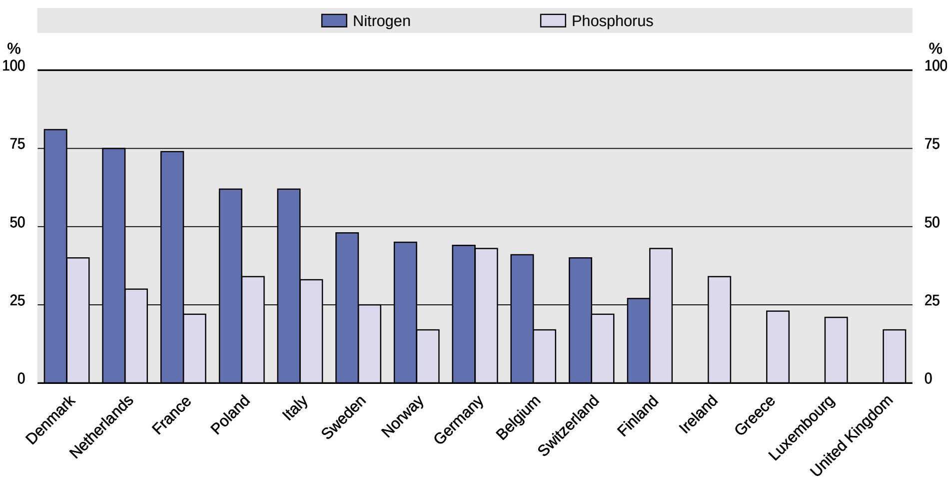
An indication of the overall OECD situation and trends for other agricultural pollutants of water, such as pesticides and soil sediment, is less clear. Extrapolating from trends in soil erosion losses and changes in pesticide use, however, would suggest that in many countries impairment of water quality from these agricultural pollutants is probably declining, but there remain serious pollution problems in some regions and countries.

Concerning pesticides, while their use has decreased in many OECD countries since the mid-1980s, the long time lag between their use and detection in groundwater means that, as with nitrates, the situation could deteriorate before it starts to improve.

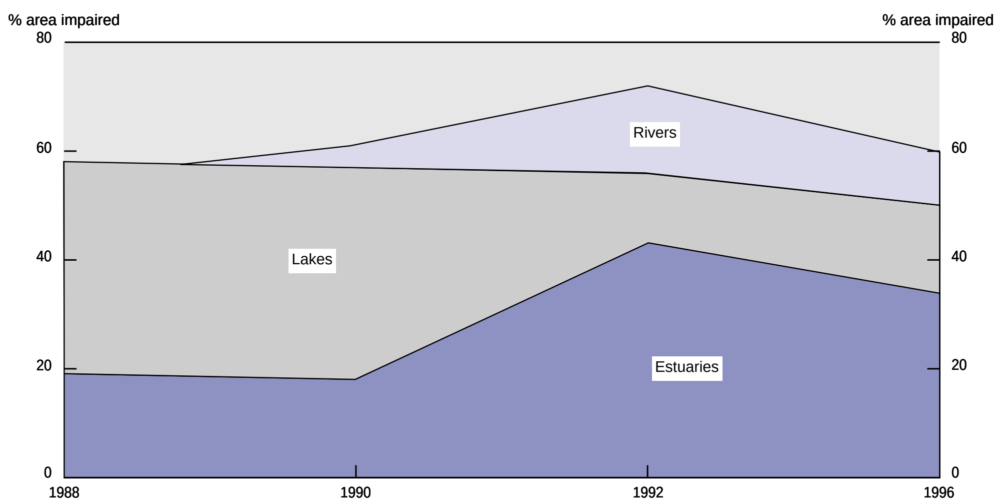
Potential nitrate concentration in water flowing from agricultural land: Denmark, 1985 to 1997



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



Share of agriculture in the impairment of surface and marine water quality: United States, 1988 to 1996



3. LAND CONSERVATION

Context

The availability of land and water resources is basic to all agricultural activity. Agriculture is often the major user of both of these resources, which can affect the flow of surface water and the loss of soil sediment from agricultural land. Appropriate land use, combined with environmentally sound soil and water management practices can help to reduce the peak flow of surface water and loss of soil sediment.

Damage caused by off-farm sediment flows is important in many OECD countries, but especially in regions where there are alternate periods of drought, which limits soil vegetation cover, followed by heavy rainfall. For countries with steep and rapid rivers and experiencing heavy rainfall, a high priority is placed on flood and landslide prevention, the consequences of which can be costly to the economy.

Indicators and recent trends

An important consideration for policy makers is to take into account the risks that are increased or mitigated by certain land use and management practices in agriculture. The measurement of such risks, can contribute to better decision-making to promote or moderate changes in land use, and appropriate management practices. Two indicators are being developed by OECD to address land conservation issues, first, the water retaining capacity of agriculture, and second, the off-farm soil sediment flow from agriculture.

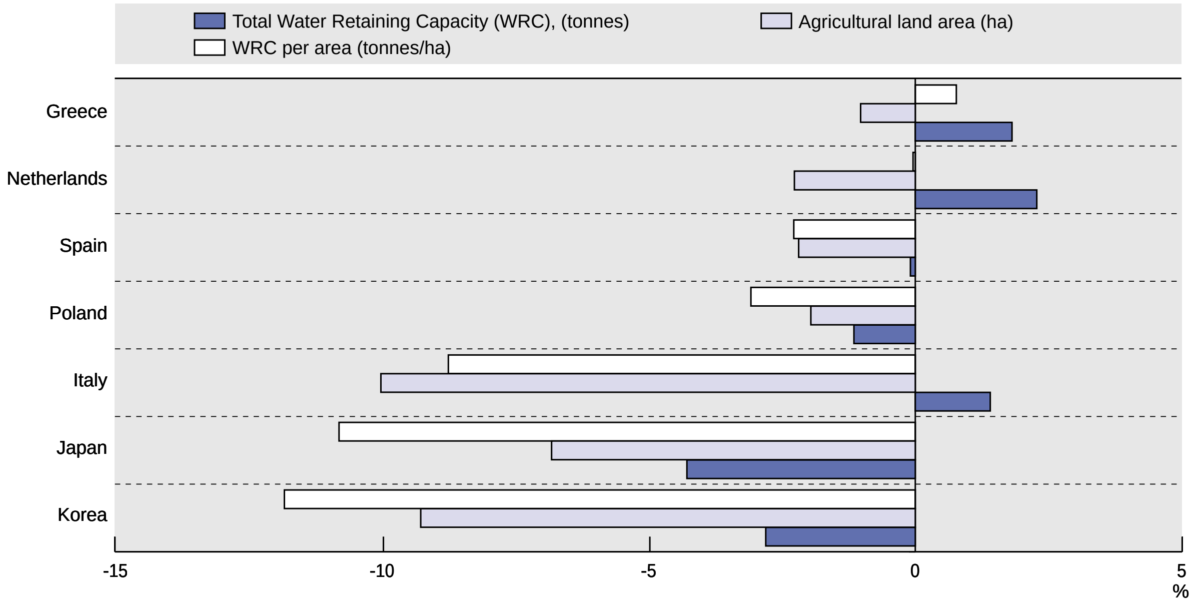
The *water retaining capacity indicator* measures the quantity of water that can be retained in the short term in agricultural soil, as well as on agricultural land, and by agricultural irrigation or drainage facilities. This indicator shows how much water a given area of land can hold taking into account differences in land use, soil types, management practices and other relevant factors. A decrease in water retaining capacity implies a greater potential risk of flooding.

The indicator of the water retaining capacity of agricultural land mainly reflects differences in land use, which vary in their capacity to retain water. There is at present a lack of information on soil types and management practices, which would help to improve the sensitivity of the indicator. On the basis of this more limited appraisal of agricultural water retaining capacity, however, most OECD countries have experienced a decrease, and only a few an increase, in water retaining capacity over the last decade.

The *off-farm sediment flow indicator* measures the quantity of soil erosion sediments delivered to off-farm areas as a result of agricultural soil erosion. The focus of this indicator is on the mitigation of soil erosion through land use and management practices, rather than just the measurement of soil erosion itself. It is not possible to show the trend of this indicator across OECD countries as the approach needs to be harmonised and data deficiencies overcome.

Some estimates, however, of the annual monetary cost of the damage to rivers, lakes and reservoirs incurred through soil sediment removal off-farm and damage to the recreational, transport and environmental functions associated with many water courses, suggest these costs are high. Evidence from related indicators on soil management and soil erosion would suggest that the rate of soil sediment flows from agricultural land to off-farm areas, especially water courses, might be decreasing for some countries.

Water retaining capacity of agriculture: 1985-87 to 1995-97



Environmental impacts of off-farm sediment flows

Sediment production	
Hungary	2-3% of eroded soil particles enter surface water bodies.
Japan	The estimated amount of off-farm sediment flow in 1987 was 9.6 million tonnes.
Mexico	Annual sediment production is 365 million tonnes, 69% of which goes into lakes and 31% is deposited in the water infrastructure.
Netherlands	Annual sediment production is 150 thousand tonnes.
Storage loss in reservoirs	
Italy	Annual storage loss due to sediments is 54 million tonnes for large dams (capacity of one million tonnes or above) and 5 million tonnes for small dams (capacity of less than one million tonnes).
Spain	Annual reservoir sedimentation amounts to 0.16% of the capacity of reservoirs (ranging from a minimum of 0.07% to a maximum of 0.25%).
Norway, Poland	Few problems with soil sediments filling up water bodies while long term effects may cause problems.
Other impacts	
United Kingdom	Agriculturally derived fine sediment is recognised as a major threat to river fish, although shoreline sediment in lakes and rivers enables aquatic faunal and vegetable life to flourish.

4. GREENHOUSE GASES

Context

It is now widely believed that the increased atmospheric concentration of greenhouse gases (GHGs) is contributing to the process of climate change and global warming. Most OECD countries, under the 1994 United Nations Framework Convention on Climate Change, committed themselves to stabilise emissions of GHGs at 1990 levels by 2000, and further agreed to implement the 1997 Kyoto Protocol, which specified the levels of emissions for the target period 2008 to 2012.

It is not only the contribution of agriculture in the climate change process, but also the impact of climate change on agriculture that is of concern to farmers and policy makers. Monitoring the role of agriculture as a source and sink for GHGs is of importance to policy makers, in view of the need for countries to assess domestic strategies, and to meet international obligations to reduce GHG emissions. Data on the specific contribution of agriculture as both a source and sink of GHG in relation to climate change, relative to other sectors in the economy, can help to develop appropriate policies.

Indicators and recent trends

The greenhouse gas indicator measures the gross agricultural emissions of three gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), expressed in CO_2 equivalents. The share of agriculture in OECD total national gross GHG emissions in CO_2 equivalents is below 10 per cent, although for methane and nitrous oxide agriculture contributes a major share in the emission of these gases, about 40 and 60 per cent, respectively. For a few OECD countries the contribution to national total GHG emissions is above 20 per cent, which is largely a reflection of the greater importance of the agricultural sector in the economies of these countries.

Livestock farming and the use of inorganic fertilisers are key sources of methane and nitrous oxide gases. The trend in agricultural emissions of GHGs has declined since the early 1990s for most OECD countries. This is mainly explained by a reduction in cattle numbers and the use of fertilisers. For a few countries GHG emissions have been rising, because of an overall expansion in crop and livestock production.

The work to date on agricultural GHG indicators focuses on emissions, because as yet there are no systematic estimates of agriculture's role as a sink for GHGs across OECD countries. Agriculture's capacity as a GHG sink is enhanced by improvements in management practices, such as tillage practices, crop cover and residue management.

The development of a comprehensive net GHG balance indicator would address both GHG emissions and removals. A number of OECD countries have begun to measure soil carbon fluxes and agriculture's capacity to act as a GHG sink. Research in *Canada*, for example, shows that net CO_2 emissions from agricultural soils in *Canada* have been considerably reduced by converting from conventional tillage to no-till systems, increasing cover cropping and improving crop residue management practices.

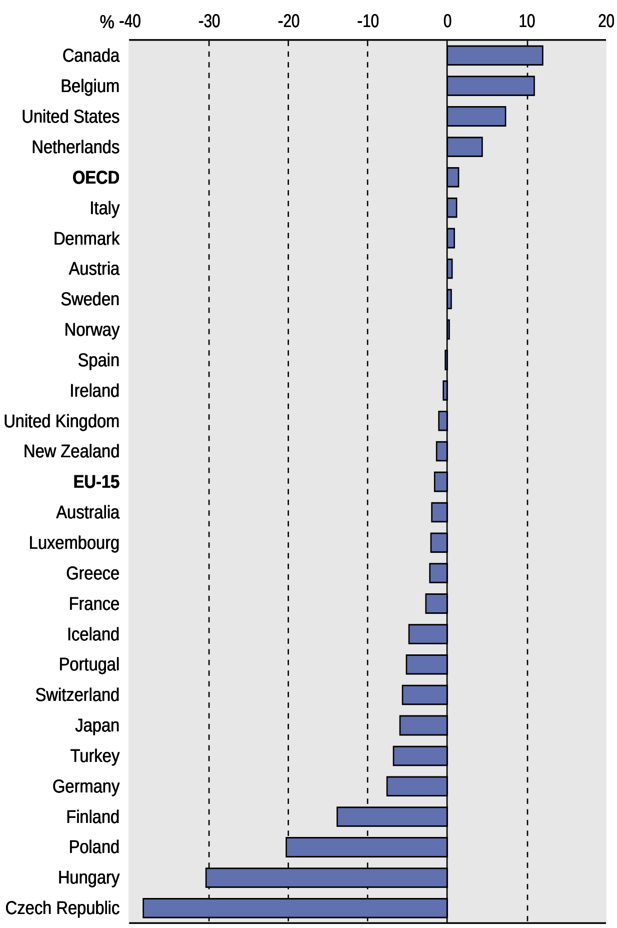
A study in *France* calculated net CO_2 emissions from changes in agricultural land use. Overall the French research showed emissions exceeded removals, with an increase in CO_2 by converting grassland to other uses and clearing forests, while agricultural land left uncultivated acted as a CO_2 sink.

Greenhouse gas emissions in carbon dioxide equivalent: 1995-97

Type of GHG	OECD total emissions	Share of each gas in OECD total	Emissions from agriculture	Share of each gas in agriculture	Share of agriculture in total of each gas
	Million tonnes	%	Million tonnes	%	%
Carbon dioxide (CO_2)	11 552	82	59	5	1
Methane (CH_4)	1 437	10	557	47	39
Nitrous oxide (N_2O)	929	7	560	48	60
Others: (HFCs, PFCs, SF_6)	224	2	0	0	0
Total	14 142	100	1 176	100	8

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 emissions

	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

5. BIODIVERSITY

Context

Agriculture as the human activity occupying the largest share of the total land area for nearly all OECD countries, plays a key role with regard to biodiversity which is highly dependent on land use. The expansion of farm production and intensification of input use are considered a major cause of the loss of biodiversity, while at the same time certain agro-ecosystems can serve to maintain biodiversity. Farming is also dependent on many biological services, such as the provision of genes to develop improved crop varieties and livestock breeds, crop pollination, and soil fertility provided by micro-organisms. In some cases non-native species cause damage to crops from alien pests and competition for livestock forage.

The main focus of policy actions in the area of biodiversity has been to protect and conserve endangered species and habitats, but some countries have also begun to develop more holistic national biodiversity strategy plans. These plans usually incorporate the agricultural sector in biodiversity conservation. At the international level a range of agreements are also important in the context of agriculture and biodiversity, most notably, the International Convention on Biological Diversity.

Indicators and recent trends

A number of biodiversity indicators are being established by OECD within the general framework of genetic, species and ecosystem diversity (the latter is covered under Wildlife Habitat indicators). The indicators provide a coherent, but initial, picture of biodiversity in relation to agriculture.

Concerning *genetic diversity*, three indicators cover the diversity of crop varieties and livestock breeds used by agriculture. Overall these indicators reveal that diversity has increased for many OECD countries since the mid-1980s, in terms of the share of varieties/breeds in total crop production/livestock numbers. This suggests agriculture has improved its resilience to environmental changes through diversifying the number of varieties/breeds used in production.

A fourth genetic diversity indicator provides information on the extent of genetic erosion and loss of agricultural plants and livestock. While information on genetic erosion or loss is incomplete, evidence for a limited number of countries suggests significant losses and/or the endangerment of loss of genetic resources in agriculture over recent decades. The collections in genebanks, however, in general continue to grow, both public and private collections.

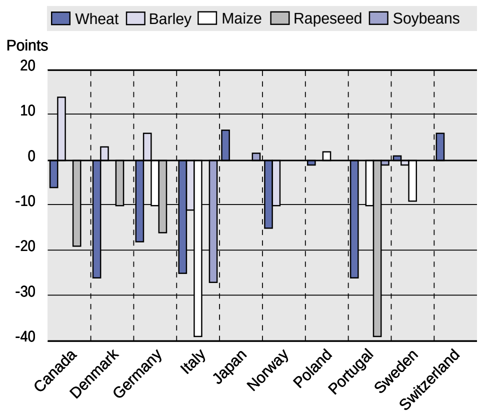
Indicators for *species diversity* cover trends in population distributions and numbers of: *i)* wildlife species dependent on or affected by agriculture, and *ii)* non-native species threatening agricultural production and agro-ecosystems.

While information on the *impact of agriculture on wild species* is limited for many OECD countries, it appears agricultural land provides an important habitat area for the wildlife that remains following the conversion to agricultural land use, but especially birds, vascular plants and some invertebrates, such as butterflies. Also, the population trends of wildlife species using agricultural land as habitat indicate in most cases a reduction over the past decade. This represents the continuation of a longer-term trend, although the decline has slowed or even reversed over recent years in some countries. Even so considerable numbers of wildlife species using agricultural land as habitat are under threat of being lost.

For *non-native species*, there is no systematic time series available across OECD countries, although their harmful effects on agricultural production and agro-ecosystems are reported for many countries. There has been a long history of non-native species introductions across countries, with the extent of economic losses to farming and damage to native biodiversity from their introduction varying widely.

Share of the one to five dominant varieties in total marketed crop production: 1985 to 1998

Change in the share of the one to five dominant varieties in total marketed production

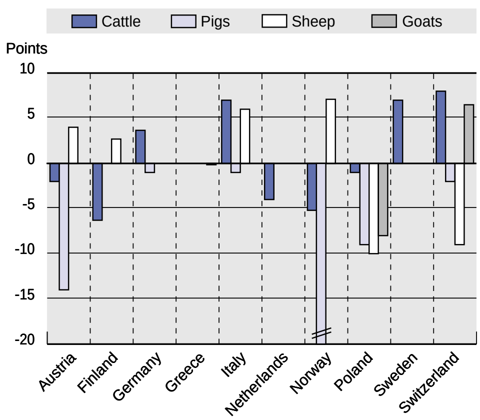


Percentage share of the one to five dominant varieties in total marketed production: 1998

	Wheat	Barley	Maize	Rape-seed	Soybeans
Canada	74	60	..	75	..
Denmark	70	71	..	82	..
Germany	41	67	47	54	..
Italy	63	42	56	100	60
Japan	83	..	..	..	50
Norway	85	80	..	100	..
Poland	59	..	37	..	..
Portugal	32	..	20	26	4
Sweden	55	58	44	..	..
Switzerland	90	..	..	90	90

Share of the three major livestock breeds in total livestock numbers: 1985 to 1998

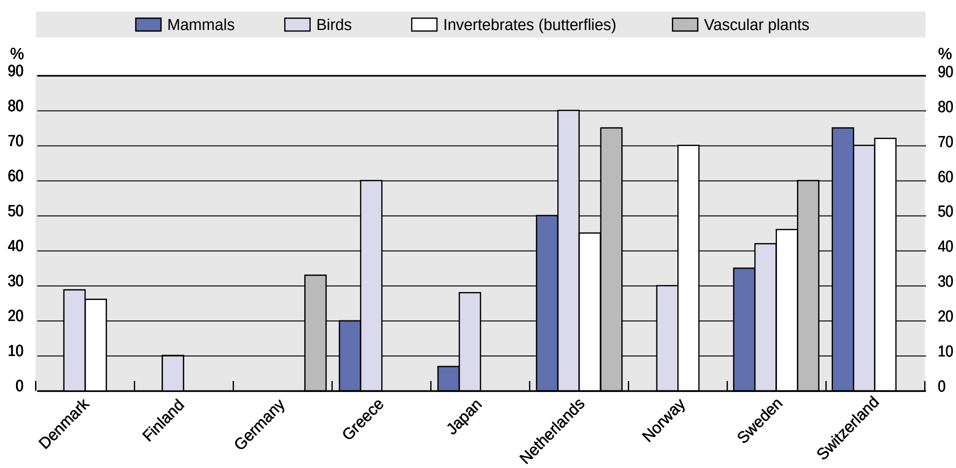
Change in the share of the three major livestock breeds in total livestock numbers



Percentage share of the three major livestock breeds in total livestock numbers: 1998

	Cattle	Pigs	Sheep	Goats
Austria	93	71	79	..
Finland	67	95	97	100
Germany	90	94	..	..
Greece	98	93	68	100
Italy	94	98	89	..
Netherlands	91	..	..	..
Norway	91	36	86	100
Poland	98	84	68	64
Sweden	92	95	..	95
Switzerland	98	98	82	74

Share of selected wild species categories that use agricultural land as habitat: 1998



6. WILDLIFE HABITATS

Context

All land, including agricultural land, provides habitat for wildlife (flora and fauna), but its composition and quality is highly variable. Agricultural activities can impact on wildlife and their habitats directly by the conversion of uncultivated natural habitats to crops or forage, and indirectly through disturbances of these habitats, such as the effects of elevated pollutant discharges.

OECD countries are paying greater attention to improving the quality of habitat on farmland because of the growing value society is placing on such habitats as sites of environmental and recreational value. Policy actions have focused on protecting endangered agricultural habitats and encouraging farmers to adopt management practices beneficial for habitat improvement, with some policy initiatives part of international commitments, such as the Convention on Biological Diversity.

Indicators and recent trends

Six indicators are being developed by OECD related to agriculture and wildlife habitat. Five indicators monitor the state and trends in intensively farmed, semi-natural, and uncultivated natural habitats. The importance of these habitats for wildlife differ widely. Intensively farmed land can be important for biodiversity where hedges, etc., are maintained, while semi-natural habitats are often rich in biodiversity. A sixth indicator is a habitat matrix, which identifies and relates the ways in which wild species use different agricultural habitat types.

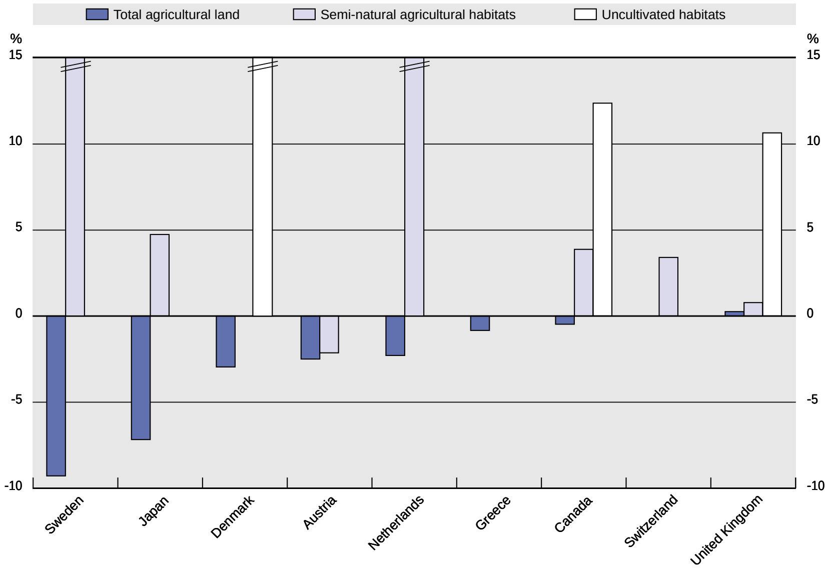
For most countries since the mid-1980s the decline in the *intensively farmed land area* (arable and permanent crops), has been more rapid than for extensively farmed land (pasture), with production on the remaining intensively farmed land increasing through improving productivity. These developments have in many cases led to the conversion of habitat to cropped land and increased pollution levels threatening and endangering wildlife species. Since the late 1980s, however, the introduction of agri-environmental and land diversion schemes has helped improve certain highly valued agricultural habitats, led to the recovery of some wildlife species, and reduced diffuse pollution. But it is too early to know the extent and permanence of these changes.

Changes in the area of *semi-natural habitats on agricultural land* show considerable variation, for the few OECD countries where data are available. For certain countries these habitats cover more than 50 per cent of the total agricultural land area and have increased since the mid-1980s, partly because land diversion schemes have led to the shift from arable land to fallow and pasture. Semi-natural agricultural habitats that have been converted to other land uses, especially to forestry, is often because of their location in marginal farming areas.

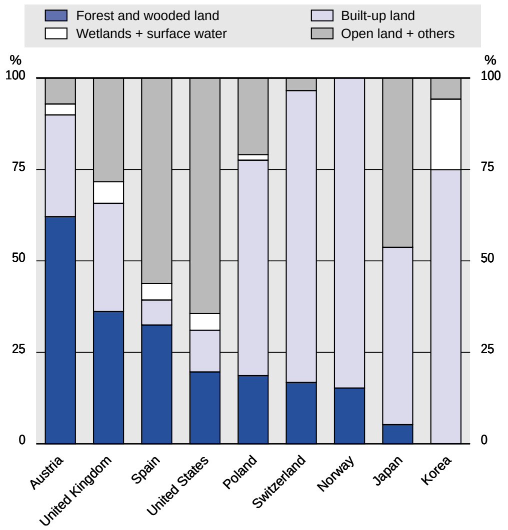
Concerning *uncultivated natural habitats,* in the case of the conversion of aquatic ecosystems and natural forests for agricultural use, there is little comprehensive data across OECD countries. For the countries where data is available, over the past decade more aquatic ecosystems are being restored than are being converted to agriculture, although for a few countries there has been a net conversion of aquatic ecosystems to farm land. The conversion of agricultural land to woodland and forest represents a significant share of total agricultural land conversion over the past decade, but it is not clear whether these changes represent the conversion to natural or semi-natural wooded areas or commercial forest.

Some countries are starting to establish a *habitat matrix* to examine the impact of agricultural land use changes on wildlife, with initial results showing that all agricultural land offers a variety of habitats for wildlife, but some types are superior to others. Also changes in land use from less to more intensive practices, such as bringing marginal land into crop production, create pressures on wildlife, such as by reducing the availability of breeding areas.

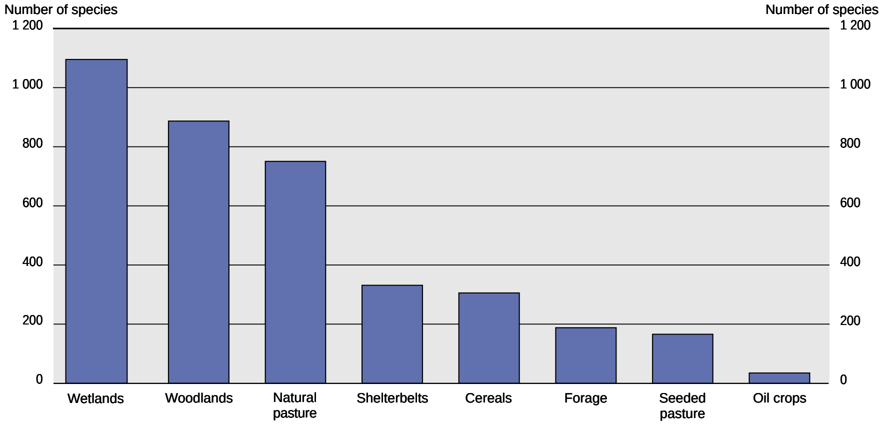
Area of total agricultural land, semi-natural agricultural habitats and uncultivated habitats: 1985 to 1998



Share of different land use types in land converted from agriculture to other uses: mid-1980s to mid-1990s



Number of vertebrates species using habitat on agricultural land: Canadian Prairies, mid-1990s



7. LANDSCAPE

Context

Agriculture plays a key role in shaping the quality of landscape, as in many OECD countries farming is the major user of land. 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.

Many OECD countries have legislation which recognises the importance of societal values embodied in landscapes and internationally some are also attracting attention, such as the designation by UNESCO of cultural landscape sites. The challenge for policy makers, because landscapes are often not valued, is to judge the appropriate provision of landscape and which landscape features society values, and assess to what extent policy changes affect agricultural landscape.

Indicators and recent trends

OECD agricultural landscape indicators provide a tool to better inform policy makers by: recording the current state of landscape and how its appearance, including cultural features, is changing; establishing what share of agricultural land is under public/private schemes for landscape conservation; and measuring the cost of landscape provision by farmers and the value society attaches to landscapes.

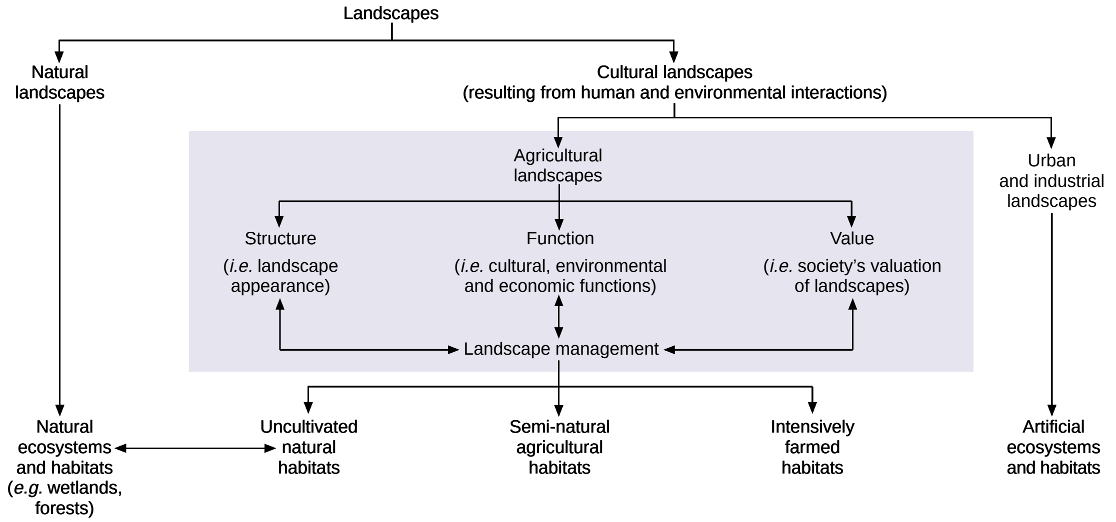
Regarding the *current state and trends in the structure of agricultural landscapes* there does seem to have been a trend towards increasing homogenisation of landscape structures in OECD countries over the past 50 years, including the loss of some cultural features (*e.g.* stone walls). This trend appears closely related to the structural changes and intensification of production, linked with the degradation of the natural resource base in agriculture.

There are signs, since the late 1980s, that the process toward increasing homogeneity of landscapes could be slowing or even in reverse in some regions. Since this period many OECD countries started to introduce a range of agri-environmental measures, including in some cases measures specifically seeking to maintain landscapes.

Public and private schemes for the conservation of agricultural landscapes are widespread across OECD countries, but mostly publicly funded. Public expenditure on these schemes tends to be a minor share of total agricultural support, but for some countries expenditure has increased rapidly. In many cases the schemes cover multiple objectives, especially concerning biodiversity, habitat and landscape conservation; and focus on the biophysical and cultural features in a local context. Some countries are beginning to include public access requirements in landscape schemes.

Currently information on the *costs incurred by farmers in landscape improvement* is extremely limited. To establish the *value society places on landscape* some countries use public opinion surveys, although as with landscape related consumer expenditure, information is limited. Non-market valuation studies 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.

Defining natural and cultural landscapes: the agricultural context



Cultural landscape features on agricultural land: 1985 to 1998

	Unit	1985	1990	1995	1998
Denmark					
Quantity					
– Farm buildings, farm yards	Hectares	. .	. .	80 000	. .
– Hedgerows, ditches and field roads	Hectares	. .	. .	c. 120 00	. .
– 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	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	Hectares	1 400 000	. .	. .	. .
– Transhumance tracks	Km	125 000	. .	. .	. .
United Kingdom					
Quantity					
– 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)	% in poor condition	. .	. .	51	. .

EXPLANATORY NOTES TO FIGURES

General notes

Readers requiring more detailed background data and information to the figures shown in this Executive Summary should consult the accompanying main report published by OECD (2001) under the title: ***Environmental Indicators for Agriculture Volume 3: Methods and Results,*** Publications Service, Paris, France, or visit the OECD web site at *www.oecd.org/agr/env/indicators.htm.*

The 30 OECD Member countries include: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The Slovak Republic became an OECD Member country in 2000, and was not included in the preparation of this Report. The Commission of the European Communities takes part in the work of the OECD.

I.1. Contextual Information and Indicators

Share of agriculture in Gross Domestic Product: mid-1990s

Agriculture as a percentage of total Gross Domestic Product (GDP), including hunting, forestry and fishing.
Source: OECD Secretariat; European Commission (1999).

Share of agricultural employment in total civilian employment: late 1990s

Employment in agriculture as a percentage of total civilian employment, including hunting, forestry and fishing. For Turkey, percentage equals 42%. The values refer to 1998 data, except 1997 for Greece and Portugal, and 1995 for Luxembourg.
Sources: OECD Secretariat; European Commission (1999).

Educational level of farmers: mid-/late 1990s

Share of farmers by educational attainment levels. "Full training" includes any training course for at least two years after school at an agricultural college, such as that completed at a university; "basic training" includes any training course completed after school at an agricultural college, such as an agricultural apprenticeship. Data for Spain, Denmark, United Kingdom, Germany and Netherlands refer to 1990. No data are available for basic training in Canada. Full training and basic training are aggregated in Norway.
Sources: OECD Agri-environmental Indicators Questionnaire, 1999; Commonwealth of Australia (1998).

Percentage Producer Support Estimate: 1986-88 to 1997-99

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. For EU and OECD, the values of the then respective member countries are presented in 1986-88 (EU:12, OECD:24) and 1997-99 (EU:15, OECD:29).
Source: OECD (2000*a*).

Share of agricultural land use in the total national land area: 1995-97
Share of agricultural land use in total national land area. "Agricultural land" includes permanent pasture, arable and permanent crops but excludes forest and woodland, urban areas, infrastructure, open land, etc. The value of Belgium includes Luxembourg.
Source: FAO Database, 1999.

Change in agricultural land area: 1985-87 to 1995-97
Percentage change in agricultural land area, as defined above. Percentages equal –23% Ireland, –12% Italy, close to zero for Iceland, equal to zero for Switzerland, and +14% for Norway. Data cover the Czech part of former Czechoslovakia, with 1985-87 refer to 1980-82. Value for Belgium includes Luxembourg. Data for 1985-87 cover western and eastern Germany.
Source: FAO Database, 1999.

I.2. Farm Financial Resources

Nominal and real net farm income from agricultural activities: mid-1980s to mid-1990s
The annual change in real farm income defined as difference between the real value of farm income (receipts from agricultural production, rents, interest and other revenues) and the real value of farm costs (marketing expenses, purchases of inputs, rates, taxes, interest and other charges and wages paid by the business). For France, United States, Korea and Finland, mid-1980s refer to early 1990s.
Sources: EUROSTAT (1998*a*); OECD (1995*a*); OECD (1995*b*); OECD (1998*a*).

Public expenditure on agri-environmental goods, services and conservation: 1993 to 1998
Public expenditure on agri-environmental goods and services, excluding research expenditure. For Sweden, programmes co-financed by EU are included from 1995 onwards. For Iceland, only includes expenditure on soil conservation and 1995 = 100. Portugal 1994 = 100.
Source: OECD Agri-environmental Indicators Questionnaire, 1999.

Share of public agri-environmental research expenditure in total agricultural research expenditure:1985 to mid-/late 1990s
Share of public agri-environmental research expenditure in total agricultural research expenditure. Early 1990s data refer to 1991 (United Kingdom, United States and Switzerland), 1993 (Japan), 1994 (Austria); and mid/late 1990s data refer to 1995 (United Kingdom), 1996 (United States), 1997 (Switzerland and Portugal), 1998 (Austria, Iceland, Japan and Netherlands)
Source: OECD Agri-environmental Indicators Questionnaire, 1999.

II. Farm Management and the Environment – Farm Management

Share of the total agricultural area under organic farming: early 1990s and mid-/late 1990s
Share of agricultural area under organic farming. Early 1990s data for Hungary, Iceland, Korea and Portugal not available. Data for the United States are taken from Welsh (1999).
Sources: OECD Agri-environmental Indicators Questionnaire, 1999; EEA (1998); Welsh (1999).

Number of days in a year that agricultural soils are covered with vegetation: mid-/late 1980s and mid-/late 1990s
Number of days in a year that soil is covered with vegetation. For Austria, data refer to 1994 and 1997. For Canada, mid/late 1980s data refer to 1981. For Sweden and Netherlands, data are not available for mid/late 1980s.
Source: OECD Agri-environmental Indicators Questionnaire, 1999.

Share of total irrigated crop area using different irrigation systems: mid-/late 1990s
Share of irrigation water applied by flooding, high-pressure rainguns, low-pressure sprinklers and drip-emitters. For United Kingdom, calculations are based on the number of holdings using irrigation and data on drip-emitters are not available.
Source: OECD Agri-environmental Indicators Questionnaire, 1999.

III.1. Nutrient Use

The main elements in the OECD soil surface nitrogen balance

Principal nitrogen inputs and nitrogen outputs (uptake) in the soil surface nitrogen balance calculation. Livestock manure excludes nitrogen losses through volatilisation of ammonia from livestock housing and stored manure.
Source: OECD Secretariat.

Soil surface nitrogen balance estimates: 1985-87 to 1995-97

Nitrogen balance (surplus/deficit) per unit area. While the calculations have been derived from using an internationally harmonised methodology, described in the previous figure, nitrogen conversion coefficients can differ between countries, which may be due to a variety of reasons. For example, differing agro-ecological conditions, varying livestock weights/yield, and differences in the methods used to estimate these coefficients. For Czech Republic, 1985-87 data refer to the Czech part of the former Czechoslovakia. For Germany as well as EU-15 and OECD, data include eastern and western Germany for the whole period 1985-97. For OECD, data refer to OECD average of all Member countries, excluding Luxembourg. Data refer to EU-15 average for the whole period 1985-97, excluding Luxembourg. For Iceland, 1995-97 data refer to 1995.
Source: OECD (2001).

Nitrogen efficiency based on the soil surface nitrogen balance: 1995-97

Nitrogen use efficiency measured as the percentage of total nitrogen uptake (output) to the total nitrogen available (input). Hungary is not included in the figure. See also notes to previous figure.
Source: OECD (2001).

III.2. Pesticide Use and Risks

Pesticide use in agriculture: 1985-87 to 1995-97

Pesticide use in agriculture as percentage change in tonnes of active ingredients. Some caution is required in comparing trends across countries because of differences in data definitions and coverage. For Denmark, France, Greece, Netherlands, Norway, Portugal, Spain, Sweden and Switzerland, "use" data refer to "sales" data. Data for 1985-87 average refer to: 1986-87 average for Greece, Korea and Spain; 1985 for New Zealand; 1985-86 average for Austria; 1987 for Italy; 1998 for Ireland and Switzerland; and 1989 for Czech Republic. Data for 1995-97 average refer to: 1994-95 average for Hungary; 1991-93 average for United States; 1994 for Canada and 1997 for New Zealand. Data for EU exclude Germany and Portugal, and for Belgium include Luxembourg. The following countries are not included in the figure: Australia (data series only exist in value terms), Germany, Iceland and Mexico (time series are not available), Portugal (data are only available from 1991); and Turkey (data are not available from 1993).
Sources: OECD Environmental Data Compendium, 1999; EUROSTAT (1998*b*); Holland and Rahman (1999).

Comparison of the environmental and health risk indicators with the quantity of pesticides sold: Sweden, 1986 to 1996

Comparison of the environmental and health risk indicators with the quantity of pesticides sold in Sweden. For convenience, the scale of the risk indicators has been adjusted to match the scale of pesticide use measured in tonnes of active ingredients.
Source: Swedish National Chemical Inspectorate.

Indicators of pesticide use and human health risks: United States, 1964 to 1992

A comparison of pesticide use measured in tonnes of active ingredients with the chronic and acute potential risk indicators. Chronic risk indicator reveals the potential human health risk from a chronic exposure to pesticides, reflecting the long-term safety/toxicity of pesticides to humans. Acute risk indicator reveals the potential human health risk from an acute exposure to pesticides, based on ingestion of active ingredients over a short period. Estimates include maize, soybeans, wheat, cotton, sorghum, rice, groundnuts, potatoes, other vegetables, citrus and apples.
Source: USDA (1997).

III.3 Water Use

Total agricultural water use: early 1980s to mid-/late 1990s

Trends in agricultural water use. "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. For UK, England and Wales only, percentage equals 124%. For Greece, Australia, Spain, Italy and Finland, values refer to irrigation water use, as data for total agricultural water use are not available. EU-15 excludes Austria, Belgium, Germany, Luxembourg, Netherlands, Portugal and, in addition for OECD, Iceland, New Zealand, Norway, Portugal, Switzerland and Turkey, because relevant data are not available.
Source: OECD Environmental Data Compendium, 1999.

Comparison of agricultural, industrial and household water prices: late 1990s

Water prices for agriculture, industry and household. Some caution is required in comparison because water supplied to agriculture is usually of lower quality than provided to households and, sometimes, industry, while the capital costs of water conveyance systems are generally lower for agriculture than for other users. Prices shown are median values for each category and in most countries prices for agriculture refer to those applied in specific regions.
Sources: OECD (1999*a*); OECD (1999*b*); OECD (1999*c*); OECD (2000*b*).

IV.1. Soil Quality

Share of agricultural land area affected by water erosion: 1990s

Share of agricultural land affected by water erosion. There are differences in agricultural land areas assessed, and the time period covered. The classification of soil erosion categories used in this figure is not necessarily that used by countries because categories were changed to aid comparison. For Italy, Portugal, Turkey and Belgium, values apply to potential/susceptible risk of erosion. Germany refers to East Germany.
Sources: OECD Agri-environmental Indicators Questionnaire, 1999, except for: Belgium: Bomans *et al.* (1996), Canada: Adapted from McRae *et al.* (2000), France: IFEN (1997), Italy: Italian Ministry of Environment (1993), New Zealand: OECD (1996), and United States: USDA (1996*a*).

IV.2. Water Quality

Potential nitrate concentration in water flowing from agricultural land: Denmark, 1985 to 1997

Potential Nitrate Concentration (PNC) is based on a thirty-year average of net precipitation (1961-90); and PNC (y-y) is based on year-to-year figures of net precipitation. Calculated precipitation minus actual evaporation is used as an estimate of net precipitation.
Source: Schou and Kyllingsbæk (1999).

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

Share of agriculture in total emissions of nitrogen and phosphorus into surface water, *e.g.* rivers, lakes. Data for nitrogen emissions are not available for Ireland, Greece, Luxembourg and United Kingdom.
Sources: Belgium: van Gijseghen and Kolder (1996, p. 122); Denmark: Christensen *et al.* (1994, p. 67-69), and EEA (1998, p. 201); France: OECD (1997, p. 59), and IFEN (1997, p. 9); Finland: Statistics Finland (1999, p. 19); Germany: EEA (1998, p. 201), and Werner (1997); Greece, Ireland, Luxembourg and United Kingdom: EEA (1998), OECD (1998*b*), Romstad *et al.* (1997), and Simonsen (1996); Italy and Portugal: EEA (1996); Netherlands: The Netherlands' Ministry of Agriculture, Nature Management and Fisheries (1995, p. 8); Norway: OECD (1993, p. 53), and Johnsen (1993, p. 400); Sweden: Ministry of Agriculture (2000, unpublished); Switzerland: Swiss Agency for the Environment, Forests and Landscape (2000, unpublished).

Share of agriculture in the impairment of surface and marine water quality: United States, 1988 to 1996

Figure shows agriculture's contribution to water pollution, from all sources (*e.g.* soil sediment, nitrogen, phosphorus, pesticides, etc.) for the one-third of the nation's water bodies assessed to be below designated water quality standards
Sources: USDA (1996*a*, 1996*b*, 1997).

IV.3. Land Conservation

Water retaining capacity of agriculture: 1985-87 to 1995-97
Percentage change of water retaining capacity (WRC) of agricultural land. Where the WRC coefficients (WRC per unit area) for certain land use types are not available or specified, those proposed by Japan are used. WRC of agricultural facilities are not included in the calculation.
Sources: OECD Agri-environmental Indicators Questionnaire, 1999.

Environmental impacts of off-farm sediment flows
Ad hoc data related to off-farm sedimentation in rivers, lakes and reservoirs in OECD countries.
Sources: OECD Agri-environmental Indicators Questionnaire, 1999; United Kingdom Environment Agency (1998).

IV.4. Greenhouse Gases

Greenhouse gas emissions in carbon dioxide equivalent: 1995 to 97
Greenhouse gas emission in carbon dioxide (CO_2) equivalent. Korea and Mexico are not included. For CO_2, 1996 data for EU countries; 1995 data for the others (Australia, Austria, the Czech Republic, Hungary, Japan, New Zealand, Poland, Switzerland, Turkey and United States are not included in the calculation). CO_2 emission in agriculture covers fossil fuel combustion only (fossil fuel combustion in forestry and fisheries is included for non-EU countries). For methane (CH_4) and nitrous oxide (N_2O), 1996-97 average for Poland and Sweden; average of 1995 and 1997 for Turkey; 1994-96 average for Australia, Belgium, Greece, Hungary, Ireland and Netherlands; and 1993-94 average for Portugal. For "Others", *i.e.* hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), 1995 data are used except 1994 for Germany (Hungary, Ireland, Luxembourg, Poland, Portugal, Spain and Turkey are not included, and only partial emissions data are included for Australia, Austria, Denmark, Finland, Greece, Iceland, Japan, Sweden and the United Kingdom).
Sources: OECD Secretariat; UNFCCC (1999); EUROSTAT (1997); Turkish Ministry of Environment (1998).

Gross emissions of greenhouse gases from agriculture: 1990-92 to 1995-97
Percentage change in gross emissions greenhouse gases from agriculture. Korea and Mexico are not included. For 1995-97 data, see notes above. 1990-92 data refer to: 1990 data for Finland, Italy, Luxembourg and Sweden; and average of 1990 and 1992 for CH_4 and N_2O in Poland and Turkey.
Sources: OECD Secretariat; UNFCCC (1999); EUROSTAT (1997); Turkish Ministry of Environment (1998).

IV.5. Biodiversity

Share of the one to five dominant varieties in total marketed crop production: 1985 to 1998
Percentage change in the share of the one to five dominant varieties in the total marketed production for selected crops. Figure shows, for Canada and Wheat for example, that for 3 wheat varieties their share in total production declined by 6% points from 80% in 1985 to 74% in 1998 (number shown in the attached table). 1985 data refer to 1990 for Portugal. 1998 data refer to: 1990 for Canada, 1995 for Poland and for Forage in Denmark. "Wheat" refers to winter wheat for Denmark, Germany, Norway and Sweden; "Barley" refers to spring barley for Denmark and Sweden; and "Rapeseed" refers to spring rapeseed for Denmark.
Source: OECD Agri-environmental Indicators Questionnaire, 1999.

Share of the three major livestock breeds in total livestock numbers: 1985 to 1998
Percentage change in the share of the three major livestock breeds in total livestock numbers. The share in 1998 is shown in the table. Figure shows, for Austria and Cattle for example, that for 3 breeds of cattle their share in total cattle numbers declined by 2% points from 95% in 1985 to 93% in 1998 (number shown in the attached table). Values beyond the range of this Figure are: –54% (pigs, Norway). 1985 data refer to: 1987 for Pigs in Germany; and 1990 for Goats and Horses in Greece, and for Cattle in Norway and Sweden. 1998 data refer to: 1995 for Cattle and Horses in Austria; and 1997 for Canada, and Cattle and Pigs in Germany.
Source: OECD Agri-environmental Indicators Questionnaire, 1999.

Share of selected wild species categories that use agricultural land as habitat: 1998
Percentage share of selected wildlife species categories that predominantly use agricultural land as habitat. 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 Agri-environmental Indicators Questionnaire, 1999.

IV.6. Wildlife Habitats

Area of total agricultural land, seem-natural agricultural habitats and uncultivated habitats: 1985 to 1998
Percentage change in the areas of total agricultural land, seem-natural agricultural habitats and uncultivated habitats. "Uncultivated habitats" refer to uncultivated natural habitats on and/or bordering agricultural land, *e.g.* woodlands, small rivers and wetlands, but for some countries includes farmyards, farm buildings, etc. Values beyond the range of this Figure are: 33% (semi-natural habitats, Sweden), 21% (uncultivated habitats, Denmark), and 547% (semi-natural habitats, Netherlands). 1985 data refer to 1984 for United Kingdom, and 1986 for Canada; 1998 data refer to 1997 for Austria.
Source: OECD Agri-environmental Indicators Questionnaire, 1999.

Share of different land use types in land converted from agricultural to other uses: mid-1980s to mid-1990s
Share of different land use types in the total area of land converted from agricultural use. "Forest and wooded land" refer to those on and/or bordering agricultural land. "Built-up land" covers mainly land used for urban or industrial development and transport infrastructure, *e.g.*, roads. "Surface water" covers mainly small ponds, lakes and diverted rivers. "Others" refer to land not used for any of the above uses, such as barren land, exposed rocks and for some countries, *e.g.* Japan, farmland abandoned but not forested. Data for wetlands not available for Switzerland, Norway and Japan; data for forests not available for Korea; and other land for Norway.
Source: OECD Agri-environmental Indicators Questionnaire, 1999.

Number of vertebrate species using habitat on agricultural land: Canadian Prairies, mid-1990s
The addition of species using the Canadian Prairies as a primary and secondary habitat for five activities, *i.e.* reproduction, feed, cover, wintering and staging (birds only). Vertebrates, including birds, mammals, amphibians and reptiles.
Source: Adapted from Neave and Neave (1998).

IV.7. Landscape

Defining natural and cultural landscapes: the agricultural context
Natural and cultural landscapes in agricultural context. The shaded area shows the main field of interest for OECD Agricultural Landscape Indicators.
Source: OECD Secretariat and personal communication with Dr. Hans-Peter Piorr (Centre for Agricultural Landscape and Land Use Research, Müncheberg, Germany).

Cultural landscape features on agricultural land: 1985 to 1998
Denmark includes 14th and 15th century churches as cultural landscape features in agricultural areas, also hedgerows in Denmark, as measured in terms of area rather than length, as they usually consist of 3-7 rows of trees and large bushes. Dehesas (in Spain) refer to wooded pastures and open grassland, used for grazing, crop cultivation and forest products. Symbols in the columns of United Kingdom are: E: England, W: Wales, GB: Great Britain. For Norway, number of farms that own or have a share in mountain farming are determined from the applications made for production subsidies for summer-mountain farming with dairy production with a minimum of 4 weeks. For United Kingdom, data for 1985 and 1995 refer respectively to 1984 and 1996, except 1993 for dry stone walls; the data on length of linear features and number of ponds are net figures.
c.: circa; ..: not available.
Sources: Norwegian Grain Corporation (unpublished); OECD Agri-environmental Indicators Questionnaire, 1999.

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