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Environmental Performance of Agriculture in OECD Countries
since 1990

Chapter 2

OECD Progress in Developing Agri-environmental Indicators

2.1. Introduction

This chapter reviews the progress of OECD work on agri-environmental indicators (AEIs), especially in a series of OECD Expert Meetings, held over the period 2001-04 (Box 2.1, *Background and Scope of the Report*, Section II). The indicators described in this chapter are those for which either methodologies and/or data sets are *not* yet at a stage that allows for representative comparative OECD country coverage, as is the case for those in Chapter 1. The OECD Expert Meetings and agri-environmental questionnaires (unpublished) provided the key material for this chapter, as well as for other chapters. Annex 2.A1 provides a list of the indicators covered in this chapter, although a few are not examined here, including the indicators of: greenhouse gases (Section 1.7.3, Chapter 1); and energy (Section 1.4, Chapter 1).

The development of OECD's AEIs has involved intensive collaboration with experts in the relevant areas, co-ordination with other international organisations, and interactive consultation with OECD countries. This chapter examines in:

- ***Section 2.2:*** A review for each indicator area, considering the relevant agri-environmental issue and definitions, followed by an assessment of how far the work has developed in each case, including identifying the main knowledge gaps that need to be addressed for the indicators to be useful for policy monitoring and evaluation; and,
- ***Section 2.3:*** Provides an overall assessment of the common themes that emerge from this review, in terms of examining the indicators against four criteria: policy relevance, analytical soundness, measurability, and ease of interpretation (see also supporting information in Annex 2.A2).

2.2. Progress in developing OECD Agri-environmental Indicators

2.2.1. Soil: Erosion, biodiversity and soil organic carbon

Soil erosion and soil biodiversity

Issues. Soil erosion resulting from agricultural activity occurs not only through the natural agency of wind and water, but also as a result of tillage translocation and mechanical intervention. It occurs across a range of landscapes and affects both agricultural productivity on-site and environmental quality off-site. The interdependence between soil erosion and soil biodiversity is widely acknowledged, thus a range of related indicators reflects the interactions between properties and processes. Damage to soil biodiversity may exacerbate erosion, and the latter accentuate biotic loss. Management practices that degrade soils can negatively impact on soil biodiversity through, for example, reducing the organic matter content, and in turn reduce soil quality. Soil biota are extremely complex and the interrelationships of soil biodiversity indicators with other variables, including soil management, are significant.

Indicators. The OECD Expert Meeting on "*Agricultural Impacts on Soil Erosion and Soil Biodiversity: Developing Indicators for Policy Analysis*" (OECD 2003a) recommended that OECD countries could develop the following indicators, in addition to those covered in Chapter 1.

Soil erosion

i) Area and share of agricultural land affected by tillage erosion in terms of different degrees of erosion, *i.e.* tolerable, low, moderate, high and severe.

ii) Contribution (as a share or physical quantity) of agriculture to off-farm sediment flows into the landscape and water bodies (from water, wind and other erosion sources).

iii) Gross on-farm soil erosion, measured through integrating models of wind, water and tillage erosion.

iv) On-farm and off-farm economic costs of soil erosion.

Soil biodiversity

No specific soil biodiversity indicators were recommended by the Expert Meeting, but experts suggested that countries could exchange information on their soil biodiversity indicator inventory, methodologies, and national case studies revealing the use of these indicators for policy analysis, where available.

Assessment. A lack of scalable, reliable, consistent and comparable datasets is the main limit to developing ***soil erosion*** indicators. In this respect, a comprehensive approach, including consistency in methodologies of modelling, of data collection and use, and collaboration among OECD countries are required in order to develop integrated indicators. While some progress has been made in developing some soil erosion indicators (Section 1.5, Chapter 1), other soil erosion indicators, see above, are less advanced. But in **Canada**, for example, risk indicators of tillage erosion on cropland have been fully developed at the regional as well as national level in addition to indicators of water and wind erosion (Lefebvre *et al.*, 2005).

Further research is needed, for example, to develop measurements of off-site deposits of eroded soil. Developing complete data systems would facilitate this process covering varying types of erosion – water, wind and tillage – as would systematic long-term monitoring (augmented by the establishment of international monitoring protocols) of all relevant variables including land use.

Soil biodiversity embraces genetic, taxonomic and functional forms which interact to provide a wide range of ecological services. Individual agricultural practices may affect this balance, therefore destabilising the ecosystem. It is generally believed that ploughing reduces diversity whilst liming tends to increase species richness in nutrient-poor and semi-natural grasslands. The over-use of agrochemicals and organic waste can also have a detrimental impact on soil organisms (OECD, 2001).

Measurement of soil biodiversity is complex (Box 2.1). Conceptual approaches can vary from taxonomic, functional, ecological, to trophic structure. Soil organisms are multifunctional, highly diverse and difficult to systematise both spatially and temporally. The heterogeneity of soil environments is a reflection of biotic activity which in turn affects biotic diversity and function. The diversity in approaches to monitoring biodiversity (at species, entity, or soil activity levels) adds to the complexity in deriving appropriate indicators.

Measuring soil biodiversity requires identification of scale (local, regional, national); the method of measurements; and the minimum set of elements needed to facilitate comparison, yet also need to reflect heterogeneity. The task is made more demanding since scientific research has varied from impact studies, population characterisation, functional analysis and methodological testing.

Box 2.1. **Soil biodiversity in agricultural land**

Soil biodiversity contributes to crop productivity, soil functions and agro-ecosystems on which the agricultural sector depends. The proper functioning of soil is essential to support life. Yet little is known about the biodiversity of soils, nor how agricultural activities can affect a soil's biological properties. Thus, a greater knowledge of the impacts of farm management practices on soil biodiversity is needed.

Several OECD countries have developed or are progressing with strategies on conserving soil biodiversity stemming from the UN Convention on Biological Diversity. The **Canadian** Biodiversity Strategy, for example, was developed in 1995 to enhance national conservation efforts on the sustainable use of biological resources. **Canada** aims to increase awareness and understanding about soil biodiversity in agriculture as research shows that the soil biotic system and its biodiversity can have wider effects with the capacity to help clean air and water (Fox *et al.*, 2003).

In the **Netherlands** there is concern over the sustainable use of ecosystems, due to agricultural use of soils. A biological indicator has been developed to assess the condition of soil quality (Anton *et al.*, 2003).

The **United Kingdom** recognises that agricultural land use and management practices may have significant (positive and negative) impacts on different components of soil biodiversity. Farmers are encouraged to consider nature conservation and environmental protection practices, as well as biomass production and heritage interests in order to maintain soil functions (Black *et al.*, 2003).

Given the complex nature of the relationships between soil biodiversity, farming practices and agricultural systems on the one hand, and groups of organisms and soil process on the other, appropriate assessment methods are necessary in this process. In this respect, a minimum set of soil biodiversity indicators, which can be adapted as further information is acquired, might include data on micro-organisms; meso- and macro-fauna; and total organic carbon.

Soil organic carbon

Issues. In response to the debates over global climate change, since 1992 the United Nations Framework Convention on Climate Change (UNFCCC) has been concerned with carbon emissions and current trends affecting the atmosphere. Emissions targets and trading in sequestered carbon or sinks are laid out in the *Kyoto Protocol* (1997). In the case of soil organic carbon, the lack of regular and consistent data on carbon stocks in agricultural soils makes it difficult to calculate accurate trends in changes in the organic carbon levels in soils.

In this context, there has been extensive research on soil organic carbon (SOC) given that longer term sequestration of SOC has the potential to mitigate greenhouse gas emissions (Rose, 2003), although the research on these relationships is still in its infancy in many OECD countries. However, this situation is expected to be improved, as the UNFCCC inventories will in future categorise carbon sequestration in agricultural soils separately from soil emissions in general (Section 1.7.3, Chapter 1). The proliferation of national carbon accounting systems is a pre-requisite for such developments, as is a framework for utilising the output of existing models and databases.

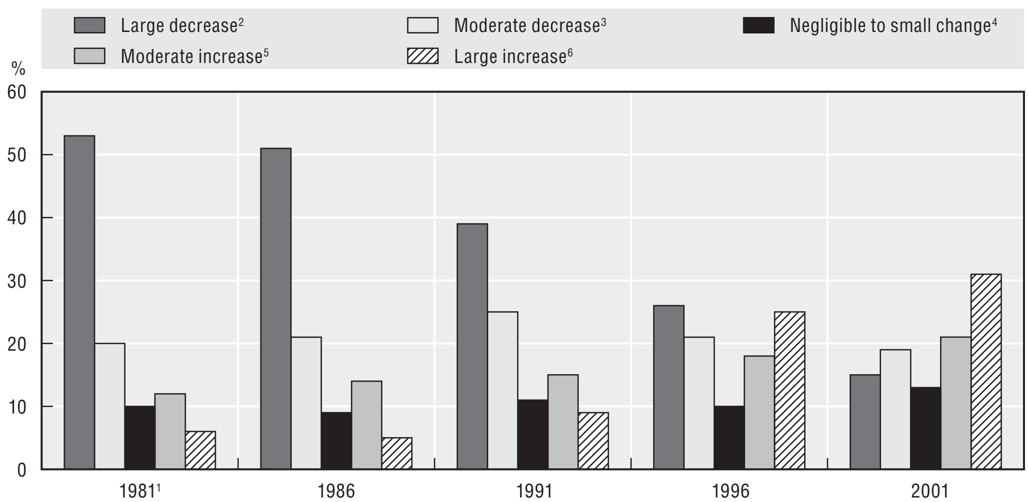
Indicators. The OECD Expert Meeting on "*Soil Organic Carbon and Agriculture: Developing Indicators for Policy Analysis*" (OECD, 2003b), recommended that OECD countries could develop the following indicator:

- Change in total soil organic carbon (SOC) in agricultural land over time.

Assessment. The high estimated opportunity cost of soil carbon in agricultural activities is a reflection of the role of soil organic matter in providing a vehicle for nutrient and water storage and release, as well as the filtration of air and water. Farm practices provide the key drivers of changes in SOC levels. The data required to explain the interactions between these variables cover not only soils, but also climate (*e.g.* degree of wind and precipitation); land use and cover; and farm management techniques. At the same time the SOC indicator needs to be considered alongside other indicators of soil and water quality, to better understand the relationships between these indicators and thus the interactions between the variables covered by them.

A few OECD countries have already begun to monitor changes in SOC and reported them to the UNFCCC. In **Canada**, the level of SOC in farmland soils increased during 1981-2001 (Figure 2.1, Lefebvre *et al.*, 2005, Liang *et al.*, 2003; Patterson *et al.*, 2003). There has been a marked increase in the share of farmland within the largely and moderately increasing class of SOC (Figure 2.1). These positive changes can be mainly attributed to improvement of crop management practices, including reduction in tillage intensity, a reduction in summer fallow on the Prairies and an increase in hay and forage crop production (Lefebvre *et al.*, 2005). Nevertheless, data for 2001 shows that Canada still has a significant share of farmland (34%) within the moderate to large decreasing class of SOC, partly due to excessive erosion on cropland with annual crops in Eastern Canada (Figure 2.1, Lefebvre *et al.*, 2005).

Figure 2.1. **Canadian soil organic carbon stocks in agricultural soils by different classes**



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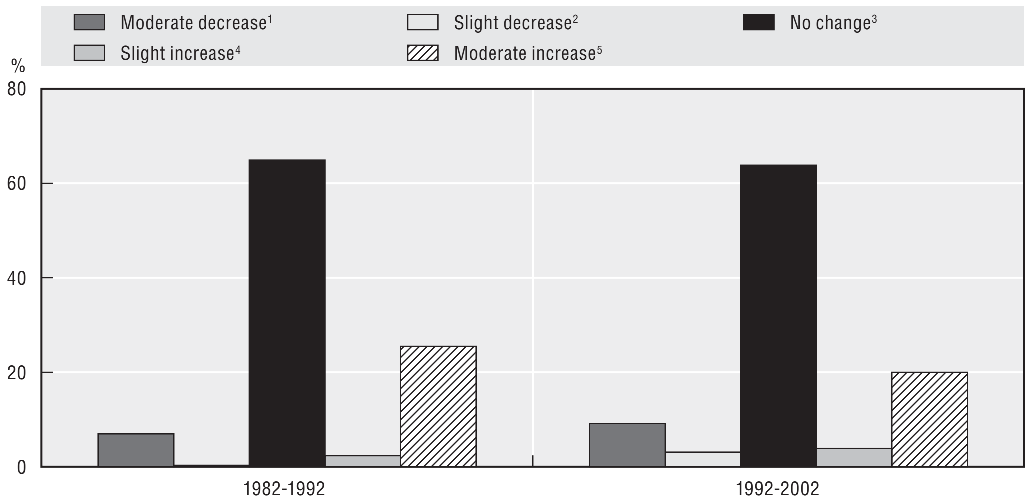
1. Slope of a 10-year regression is taken, centred on each particular year indicated.
2. Large decrease is defined as more than 50 kg decrease in soil carbon per hectare per year.
3. Moderate decrease is defined as between 10 and 50 kg decrease in soil carbon per hectare per year.
4. Negligible to small change is defined as between –10 to 10 kg change in soil carbon per hectare per year.
5. Moderate increase is defined as between 10 and 50 kg increase in soil carbon per hectare per year.
6. Large increase is defined as more than a 50 kg increase in soil carbon per hectare per year.

Source: Lefebvre *et al.*, 2005.

Agricultural soils in the **United States** sequester around 4 million tons of carbon annually, accounting for about 2% of total terrestrial carbon. SOC stocks in agricultural soils declined between 1982 to 1992 but overall changed little over the period 1992 to 2002 (Figure 2.2; USDA, 2004). While adoption of conservation tillage practices have helped toward increasing SOC, more extensive implementation of conservation management practices could lead to sequestration at much higher rates (Ogle *et al.*, 2003).

Figure 2.2. **United States soil organic carbon stocks in agricultural soils by different classes**



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1. Moderate decrease is defined as more than 50 kg decrease in soil carbon per hectare per year.
2. Slight decrease is defined as between 10 and 50 kg decrease in soil carbon per hectare per year.
3. No change is defined as between –10 and +10 kg change in soil carbon per hectare per year.
4. Slight increase is defined as between 10 and 50 kg increase in soil organic carbon per hectare per year.
5. Moderate increase is defined as more than 50 kg increase in soil organic carbon per hectare per year.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

Analytical and sampling protocols are required to ensure consistency and comparability, particularly with respect to soil profile depth. A major concern involves measuring potentially very small changes in SOC that might occur within a short time period. Model choice should be determined by biophysical heterogeneity and data availability. The dynamics of carbon and nitrogen cycling are closely linked and other indicators, such as some soil biodiversity indicators, can be extracted from the data sets that produce the SOC indicator.

2.2.2. Water: Use and water quality

Issues. Agriculture is a significant user of water and the main contributor to water pollution in rural areas of many OECD countries. While the links between the use and quality of water are pronounced in some cases, agriculture can, at the same time, provide eco-systems services such as groundwater recharge and flood control. In this context, indicators with respect to water use and quality are crucial to reflect the current status and trends in these variables, as well as links to agricultural water management indicators.

Indicators. The OECD Expert Meeting on "*Agricultural Impacts on Water Use and Water Quality: Developing Indicators for Policy Analysis*" (OECD 2004a) recommended that OECD countries could develop the following indicators, in addition to those covered in Chapter 1:

Water use

1. A net agricultural groundwater balance to take into account both agricultural withdrawals and recharge of groundwater.
2. Annual share of rivers/lakes where agricultural water extraction results in rivers/lakes falling below (seasonal) a minimum reference level.
3. Impact of agricultural water use on ecosystem health (*e.g.* wild species and wetlands).
4. Trend in the average value of irrigated agricultural product(s) per unit of irrigation water consumed (or alternatively water withdrawn or licensed water allocation, where the water withdrawn could be the *gross* value of total water withdrawn or the *net* value of total water withdrawn minus the value of water returned to rivers and lakes and recharged to groundwater).
5. Charges for water supplies to farmers relative to water supply charges for other major users (industry and urban).

Water quality

1. Salt concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas.
2. Pathogen (faecal indicator or pathogenic bacteria) concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas.
3. Share of pathogen contamination derived from agriculture in surface waters and groundwater.

Assessment. With respect to groundwater use, measuring the net balance (as opposed to outward flows) would provide a more comprehensive indicator, with the information augmented by data on the quality of outward and return flows (Section 1.6.1, Chapter 1). In this regard, recharge of groundwater as well as return flows to rivers has been measured in countries, such as in **Japan** and **Korea** (Table 2.1).

Table 2.1. **Net water balance in a Japanese rice field irrigation system: 2003**

	10 000 m^3/1 000 ha/120 days
Input (into rice field)	**2 220**
Intake from river	1 920
Rainfall	900
Withdrawal evapotranspiration	600
Output (from rice field)	**2 220**
Return flow to a river	1 370
Groundwater recharge[1]	450
Other	400
Ratio of return flow to river/intake from river (%)	71
Ratio of groundwater recharge/intake from river (%)	23

StatLink http://dx.doi.org/10.1787/301817702474

1. A part of water is discharged into downstream rivers after groundwater recharge.

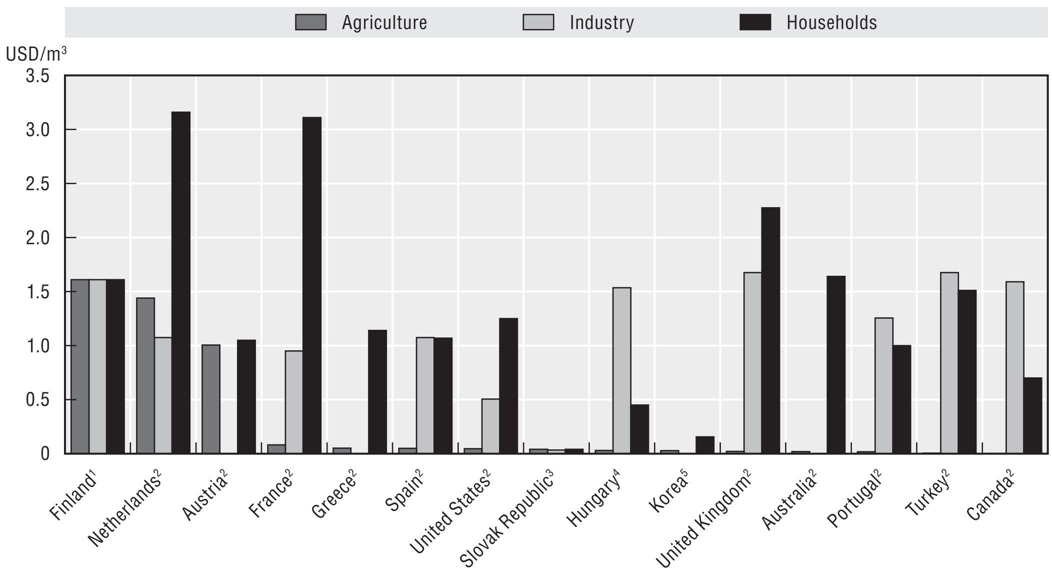
Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

Indicators of volumes used in, and area under, irrigation could describe one aspect of water use efficiency, with a related indicator describing economic efficiency or agricultural output per unit of water consumed. In the **United States**, for example, the average value of irrigated agricultural products per unit of irrigation water is more than four times higher than that of non-irrigated products. Water use indicators may also need to reflect humid as opposed to arid and semi arid conditions.

The indicator of charges for water supplies to farmers relative to water supply charges for other major users (industry and urban) reveals that in many OECD countries agricultural producers pay substantially less for water deliveries than industrial and urban users (Figure 2.3). To an extent the difference in water charges between agriculture and others users reflects the widespread support provided to OECD irrigated farming (Chapter 1). Some caution is required, however, in comparing agricultural water charges with other user charges because water supplied to agriculture is usually of a lower quality than that provided to households and, on occasion, industry; while the capital costs of water conveyance systems are generally lower for agriculture than for household or industry. In addition, variations in water charges between users may not reflect differences in water use efficiency, for example, public water supplies in a particular water catchment

Figure 2.3. **Agricultural, industrial, and household water charges**

Late 1990s-early 2000s



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

1. Data from OECD Agri-environmental Indicators Questionnaire, unpublished.
2. For agriculture, industry, and households, charges are the median values for the range of charges for each category, and data for late 1990s, see OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France. Agricultural water charges are less than 0.1 USD/m^3.
3. The charges for water used by agriculture and households are the same (0.04 USD/m^3) but for industry are lower (0.034 USD/m^3), data for 2002.
4. Agricultural water charges are less than 0.1 USD/m^3, data for 2003.
5. For households and industry, water charges are for the year 2000, and for agriculture (paddy field), for the year 1995. Agricultural water charges are less than 0.1 USD/m^3.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

might be drawn from groundwater while that for agriculture from a river. Moreover, water charges may not reflect the value of positive externalities that can be generated by agriculture, such as groundwater recharge, as discussed above.

The development of water quality indicators is complicated because different reference levels are used to define national quality standards, ranging from drinking water to other water uses, including for environmental and recreational use. Similar issues arise with respect to salt and pathogen content, where there are no common standards or indicators across countries (Box 2.2).

Refinement of current measurement techniques of water use and quality is necessary, but the main need of future research is to broaden the range of indicators and associated data, to include measurements of the environmental and social consequences for water

Box 2.2. **Agricultural livestock pathogens and water pollution**

Pathogens in livestock manure (*e.g.* bacterial, parasites and medicines), especially from dairy cattle and pigs, can be transmitted in waterways directly from faecal discharges, leaking slurry/manure stores and from field application of manure. These pathogens can damage fish and shellfish in aquatic ecosystems, and cause human health problems through impairing drinking water quality. There is little information available about how the release of these pathogens into water bodies may affect human health or eco-systems. However, a study in the **United States** found that 9% of farm streams registered positive for several pathogens due to the frequency of manure spreading (OECD 2004b).

Many OECD countries have established guidelines or standards for pathogens in water bodies, in particular drinking water. For example, national guidelines exist for *E. Coli*, which must be undetectable in at least 100 ml of drinking water, in **Canada, Japan, Korea, New Zealand** and the **European Union.** Whilst methods of establishing standards may differ between OECD countries, they all share the objective of reducing water contamination to protect aquatic life and ensuring the safety for human consumption of water.

About 1 000 **Canadians** suffer from *E. Coli* annually, with the majority of recent cases relating to consumption of infected meat or cheese. In May 2000, seven people died and more than 2 000 became ill when the water system of an Ontario town was contaminated with *E. coli*. It is believed that the contamination came from cow manure that had leached into the water table. *Canada* also operates guidelines for freshwater and marine waters and has identified "at risk" areas where higher pathogenic bacterial contamination of surface or groundwater is likely. This especially occurs next to intensive livestock production.

In **Germany** studies show that the harmful effects of pathogens from livestock are reduced in the soil and groundwater aquifers within 50 days of their release in such a way they do not impair drinking water quality. For this reason, slurry and manure application is forbidden in specified water abstraction zones taking into account groundwater leaching velocity and the 50-day release threshold. For example, if the groundwater velocity amounts to 1 metre per day no livestock waste application is allowed around the pumping within a distance of 50 metres).

In the **United Kingdom** investment in the sewerage industry's infrastructure has significantly improved the quality of surface water bodies and highlighted areas where diffuse pollution from agriculture is compromising "guideline" standards, in particular North-West England and Western Scotland. Research is currently being conducted to identify the proportion of contamination derived from agriculture.

use and quality resulting from agricultural activity. There is currently a lack of information regarding these environmental and social interactions, as well as on agriculture's provision of ecosystem services, and the impact of agricultural water use on aquatic ecosystems (Box 2.3). Additionally, better understanding of the links between water use and quality could facilitate the development of both sets of indicators as, particularly with respect to irrigation water, these links can be significant.

Box 2.3. **The impact of agriculture on aquatic ecosystems**

Changes in river flow patterns contribute to the disturbance or degradation of aquatic ecosystems. There is an intricate balance between water levels in rivers, wetlands, groundwater sinks, etc., which can be disrupted by the disproportionate use of one of these resources. For example, withdrawal of excessive amounts of groundwater (in excess of the rate of recharge) can cause the reduction of river flows, the complete stoppage of flows or in severe cases the drying up of streams or the reversal of river flows.

Defining minimum flows for rivers is important to safeguard the water levels in rivers and streams. Monitoring water levels and the quality of rivers will indicate the extent of human interference and the effects of natural events (*e.g.* flooding or drought). Where river flows are regulated, it is expected that aquatic ecosystems can be relatively undisturbed.

Data are limited on the effect that over-extraction of water either from rivers or groundwater for agricultural purposes has on river flows or aquatic ecosystems. In some OECD countries in **Australia, Europe** and **North America** they have experienced problems in retaining minimum river flows as a result of overexploitation by irrigated agriculture. Therefore, monitoring minimum water flow rates in rivers is becoming a key part of environmental planning in river basins.

Source: OECD (2001).

Although current approaches to measuring these indicators have yielded valuable information, other frameworks and methodologies may improve understanding of agriculture's impact on water use and quality, particularly with respect to differentiating impacts by source. In this respect, the impact of alternative farm and water management practices may lead to helpful insights and the use of frameworks that encompass spatial scales that vary from the local to the international level.

2.2.3. Biodiversity: Genetic, wild species and ecosystem diversity

Issues. OECD has developed an Agri-biodiversity Framework to help organise and identify suitable agri-biodiversity indicators (Section 1.8, Chapter 1). In addition, the biodiversity indicators in Chapter 1 take account of the *Convention on Biological Diversity* identification of three levels of biodiversity: the genetic, species and ecosystem levels.

Indicators. The OECD Expert Meeting on "*Agriculture and Biodiversity: Developing Indicators for Policy Analysis*" (OECD, 2003c) recommended that OECD countries could develop the following indicators, in addition to those covered in Chapter 1:

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Genetic resource diversity

- Number and share of national native crop varieties (*i.e.* cereals, oil crops, root crops, fruit and vegetables) that are considered to be at risk of extinction (*i.e.* critical or endangered risk status).

Wild species diversity

- Number of ecologically indicative wild species using agricultural land.

Ecosystem diversity

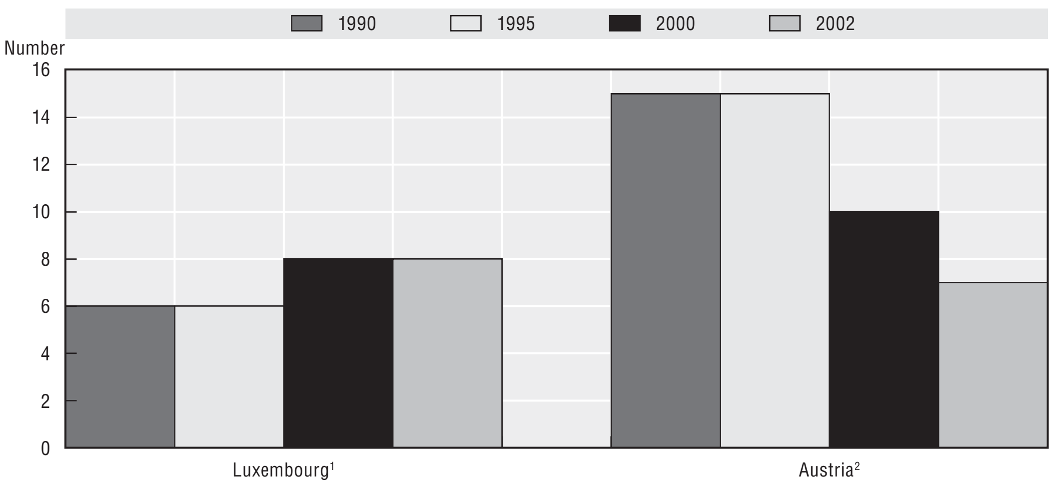
- Quality and quantity of habitat features (*e.g.* patch size, linear features and networks) and their spatial composition (*e.g.* fragmentation, vertical structures, mosaics) across agricultural land.

Linkages between habitats and species

1. *Habitat-Species Matrix*, linking changes in the area and management of all agricultural habitat types on wild species (flora and fauna) through data from either explicit field observation or indirect information (*e.g.* expert knowledge).
2. *Natural Capital Index*, the product of the quantity of agricultural habitat types and their quality in terms of wild species abundance, richness, habitat structure and management, measured between the current state of the agro-ecosystem and a baseline state.

Assessment. For indicators related to the ***diversity of genetic crop resources***, only a few countries have developed a database on the national crop varieties that are extinct, critical or endangered from being lost, or not at risk (Figures 2.4 and 2.5). The **United States** also reports genetic erosion is less of a problem for wheat and maize, although genetic uniformity of rice, beans and minor crops is a concern (Chapter 1). Identifying crop varieties that are endangered can be difficult. For example, a plant variety may be endangered *in situ*, but the genetic material of the variety could be held *ex situ* in a gene bank.

Figure 2.4. **National crop varieties that are endangered**



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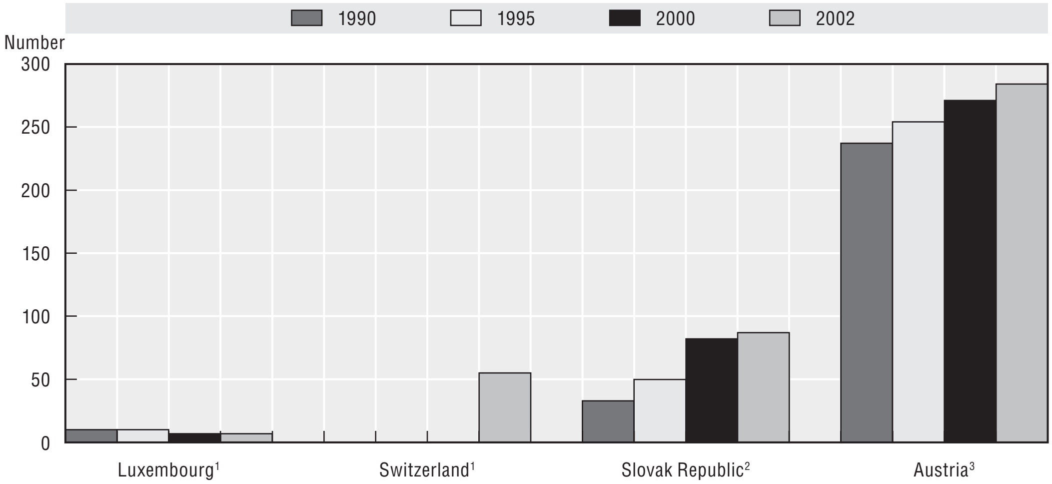
1. Crop varieties include fruit and vegetables.
2. Crop varieties include: cereals, oil crops and fruit.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

Figure 2.5. **National crop varieties that are not at risk**



StatLink http://dx.doi.org/10.1787/288456310701

1. Crop varieties include only fruit.
2. Crop varieties include: cereals, oil crops, root crops and vegetables.
3. Crop varieties include: cereals, oil crops and fruit.

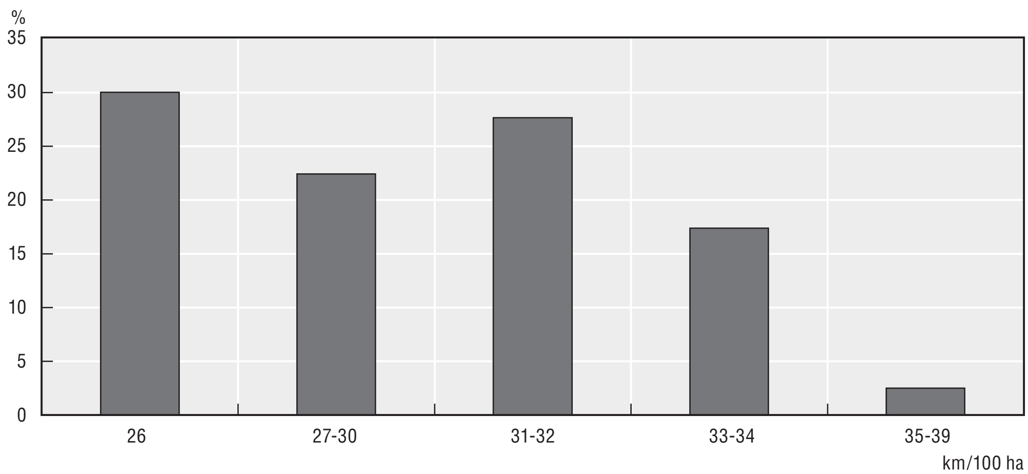
Source: OECD Agri-environmental indicators Questionnaire, unpublished.

Some progress has been made across OECD countries in developing indicators of ***wild species***, especially bird populations (Section 1.8.2, Chapter 1). But data and indicators related to other wild flora and fauna species are poorly developed.

Some progress is being made on the analysis of ***ecosystem diversity***, especially in terms of improved monitoring of agricultural semi-natural habitats (*e.g.* improving the distinction between different types of grasslands). In addition, some countries are developing methods and measurements of the quality of agricultural habitats, notably the structure of habitats. For example, **Finland** has developed an indicator of the edge density of field margins (Figure 2.6; Hietala-Koivu, 2003), which shows the abundance (or lack) of the ditch

Figure 2.6. **Edge density of agricultural fields in Finland**

2002



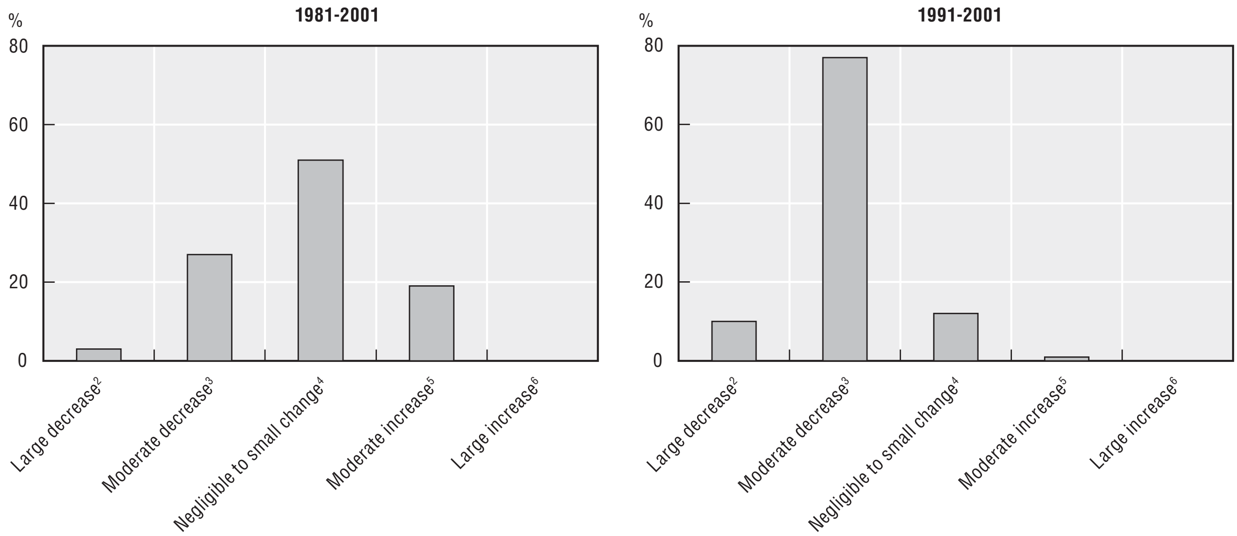
StatLink http://dx.doi.org/10.1787/288472430331

Source: Hietala-Koivu (2003).

boundaries between fields and other forms of land use (*e.g.* forest, roads). The indicator also shows the regional variation in edge density, and that where edge density is low this is likely to adversely impact biodiversity and cultural landscape values.

Habitat-Species Matrix and *Natural Capital Index* indicators integrate habitat quantity and quality indicators to provide information on how land use and land cover changes are affecting wild species (flora and fauna) in their use and requirements of habitats in agro-ecosystems (OECD, 2003c). The *Habitat-Species Matrix* (termed as a habitat capacity index in Canada) has been developed in some countries, such as **Canada** that aims to improve understanding of how wildlife habitats on agricultural land could be affected by sectoral, market and policy changes (Lefebvre *et al.*, 2005). In Canada, while a moderate improvement (increase) in habitat capacity was observed on nearly 20% of farmland between 1981-2001, there was a corresponding reduction in habitat capacity (moderate and large decrease) on nearly 30% of farmland (Figure 2.7). This was mainly occurred during 1991 to 2001 due to an expansion in cropland and decline in species-rich natural pasture (Lefebvre *et al.*, 2005).

Figure 2.7. **Share of Canadian farmland in various classes of the habitat capacity index**[1]



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1. The habitat capacity index is calculated by relating the number of species that use each of the five selected land cover categories (*i.e.* cropland, summerfallow, tame pasture, natural pasture and "all other land") to the relative area occupied by each land cover type.
2. Large decrease is defined as more than a 10% decrease during the period in each figure.
3. Moderate decrease is defined as between a 2.5% and 10% decrease.
4. Negligible to small change is defined as between a –2.49 and 2.49% change.
5. Moderate increase is defined as between a 2.5% and 10% increase.
6. Large increase is defined as more than a 10% increase.

Source: Lefebvre *et al.*, 2005.

The *Natural Capital Index* (NCI) is being developed in the context of the implementation of the Convention on Biological Diversity (OECD, 2001). The NCI is calculated as the product of the quantity of the ecosystem (*e.g.* agro-ecosystem) multiplied by the quality of the ecosystem (*i.e.* average of changes in wild species numbers from a baseline period), and has similarities with the habitat-species matrix. The **Netherlands** has been active in developing the NCI, both at the broad national ecosystem level and for agro-ecosystems, tracking the decline in natural capital associated with agro-ecosystems in the country (Brink, 2003; RIVM, 2004).

2.2.4. Land: Landscapes and ecosystem functions

Agricultural landscapes

Issues. Agricultural landscape indicators attempt to show the relationship between agricultural structures and practices, and landscape structures, functions and values. These relationships are complex, often highly site specific and open to differing interpretations, reflecting the diverse situations among countries.

Indicators. The OECD Expert Meeting on "*Agriculture Impacts on Landscapes: Developing Indicators for Policy Analysis*" (OECD 2003d) recommended that OECD countries could develop the following indicators:

1. Landscape Structure: land use, cover, patterns and cultural features (*e.g.* hedges and historic farm buildings), some of which are partly covered in other indicator areas.
2. Landscape Functions: recreation (*e.g.* accessibility), cultural identity, tranquillity, and ecosystem functions covered in the biodiversity indicator area.
3. Landscape Values: monetary value of agricultural landscapes calculated through the use of methods, such as contingent valuation.

Assessment. Agricultural landscape indicators should ideally cover three areas: structures; functions; and societal value. Where local/regional landscape targets (*e.g.* cultural elements) have been defined, the national level indicator could be expressed in terms of the percentage of regions or sub-regions that meet their own targets. Management practices which also affect landscape are also considered in the context of the farm management group of indicators (Section 2.2.5).

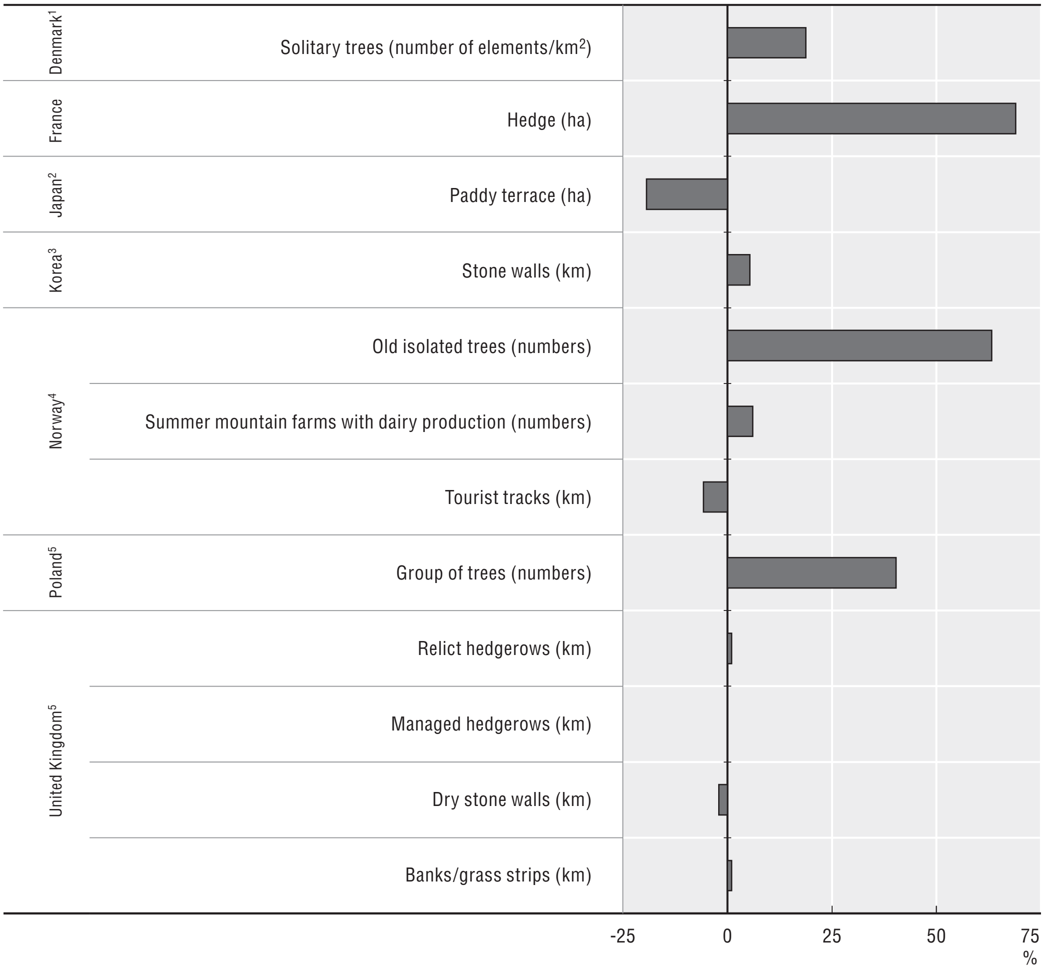
With regard to indicators of agricultural function and values, no consistent data across OECD countries are available, as a range of different methods has been adopted or are under development, while marked differences in data gathering activities (*e.g.* surveying or sampling landscape, collection of statistical data) also exist between OECD countries. In this context, the current emphasis has focused on landscape structure such as land use, cover, patterns and cultural features, such as stone walls, historic buildings, etc., in terms of recording the current status and change rather than anticipating future trends.

Regarding landscape structures, much less information is available concerning land cover, patterns and cultural features across OECD countries compared to land use. Nevertheless, in the case of cultural features, several countries have measured these changes over the past decade (Figure 2.8). The changes in these elements have been usually measured at the regional level, in particular, in **Europe**. For example, the European Environment Agency has established comparable agricultural landscape indicators, such as measuring field patch density and linear features (EEA, 2005).

For a more comprehensive approach, an Agri-Landscape Indicators Framework which was developed through the OECD Expert Meeting on Landscape, could be used by countries (OECD, 2003d). This links the range of indicators expressed through regional and local targets to policy objectives. But more research is needed to understand the linkages between policy and landscape development. Few countries have clearly defined targets for landscape conservation, or have undertaken trend analyses of landscape feature developments. In this respect, future emphasis on spatial differences is appropriate.

Figure 2.8. **Cultural landscape features on agricultural land**

% change 1990 to 2000



StatLink http://dx.doi.org/10.1787/288557083627

1. Data for 1990 and 2000 refer to 1991 and 1996, respectively.
2. Data for 2000 refer to average of 2001-03.
3. Only in Cheju Provincial Area.
4. Data for 2000 in tourist tracks refer to 1995.
5. Data for 2000 refer to 1998.

Source: OECD (2001); OECD Agri-environmental Indicators Questionnaire, unpublished.

The current emphasis on structural indicators could be broadened to capture more fully the functional diversity of landscapes (recreation, cultural identity, tranquillity); farm management variables (farming systems, landscape provision); and societal demand. A better understanding of the relationships between these and other indicators, together with refinement of the methodologies of data collection and greater uniformity of techniques used by different countries in data collection, would be necessary to use these indicators in policy analysis.

Land ecosystem functions

Issues. There are a range of ecosystem functions or services associated with agriculture, and land ecosystem function indicators are designed to reflect changes in the provision of some of these services. An illustrative example of ecosystem services linked to agriculture concerns the potential of farming to help control the incidence and severity of floods and landslides. Increasing climate variability is leading to the growing incidence and severity of flooding and landslides in many regions across the world. Agriculture can be both the cause and solution to help mitigate damage from floods and landslides depending on various factors including which farming practices and systems are adopted.

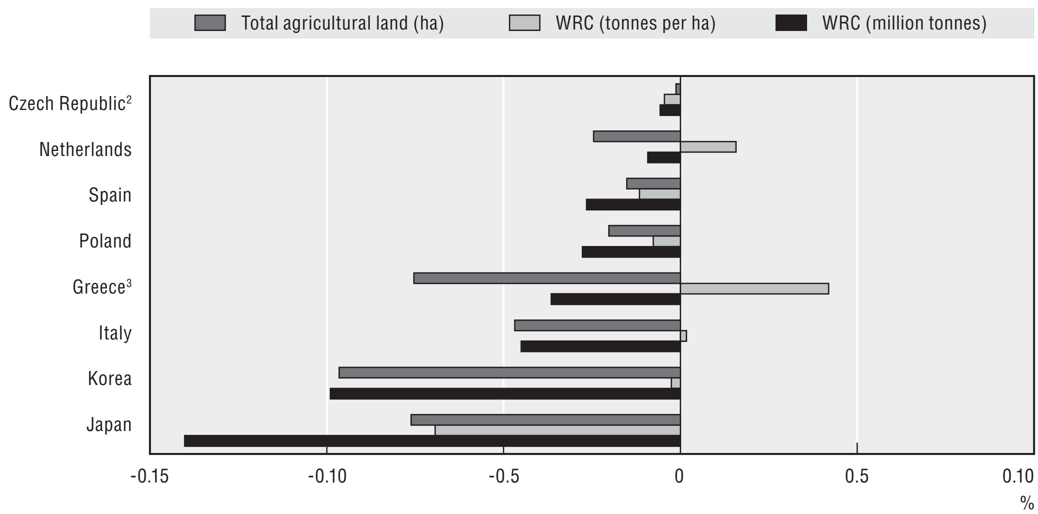
Indicators. The OECD Expert Meeting on "*Agriculture and Land Conservation: Developing Indicators for Policy Analysis*" (OECD, 2004c) recommended that OECD countries could develop the following indicators:

1. Water retaining capacity (WRC): quantity of water that can be retained in the short term, in agricultural soil, as well as on agricultural land where applicable (*e.g.* flood storage basins) and by agricultural irrigation or drainage facilities.
2. Water retaining capacity by agricultural irrigation or drainage facility (Wf): extent to which on-farm water storage facilities retain water (*e.g.* on farm dams, dykes, canals, etc.).
3. Landslide mitigation index (LMI): proportion of managed agricultural land within the agricultural land area subject to landslide risk.

Assessment. The WRC indicator describes the quantity of water that can be retained in the short term by agricultural soils; on agricultural land such as flood storage basins; and by on-farm water storage such as irrigation and drainage facilities. The lack of available national coefficients of WRC per area is the main constraint in developing this indicator. Nevertheless, the WRC has been calculated for several countries and shows that the WRC has declined in all countries over the past decade (Figure 2.9). Also the indicator of water retaining capacity of farm irrigation or drainage facilities (Wf), varied among countries

Figure 2.9. **Water retaining capacity of agriculture**[1]

% change 1990-92 to 2000-02

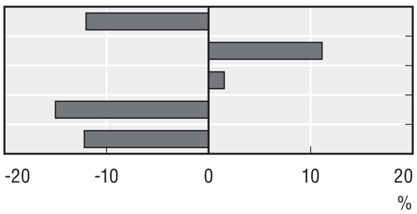


StatLink http://dx.doi.org/10.1787/288607865006

1. The WRC of agricultural facilities is not included.
2. Data for 1990-92 refer to 1993.
3. OECD estimates for WRC coefficients based on OECD (2001).

Source: FAO Database; OECD (2001); OECD Agri-environmental Indicators Questionnaire, unpublished.

Figure 2.10. **Water retaining capacity for agricultural facilities**



	% change 1990 to 2002	1990	2002
		Million tonnes	
Korea	–12	3 758	3 295
Switzerland	11	0.9	1
Slovak Republic[1]	2	65	66
Japan	–15	5 897	4 987
Italy[2]	–12	5 155	4 527

StatLink http://dx.doi.org/10.1787/288657022861

1. Data include small dams only.
2. Data for 2002 refer to 2000.

Source: OECD Agri-environmental Indicators Questionnaire, unpublished.

(Figure 2.10). In countries where both the WRC and Wf indicators have declined significantly, such as **Italy** and **Japan**, it is implied that the potential risk of flooding has increased during the past decade.

The WRC indicator could be further improved by taking into account different soil conditions and farm management practices, while the Wf indicator could also be further developed to reflect the ability of agriculture to retain water during periods of drought. An approach that includes the water retaining capacity of non-agricultural land use, within the catchments, would provide a more holistic view of the potential of different land use types (*e.g.* agriculture, forest) to help mitigate floods and landslides. A few countries have also begun work on developing the landslide mitigation indicator (**Hungary** and **Japan).** More generally land ecosystem function indicators could be better integrated into policy analysis and contribute to international initiatives, such as the projects of the International Flood Network launched during the Third World Water Forum in 2003.

2.2.5. Farm management

Issues. The focus of farm management has changed over time to include productivity within the broader concept of sustainability. Farming systems are constantly evolving and their environmental impact is always complex, reflecting the interaction of the key agents in this process: farmers, policy makers, and markets. A more holistic and environmental focus on farm management indicators needs further development, in addition to those covered in Section 1.9, Chapter 1.

Indicators. The OECD Expert Meeting on "*Farm Management Indicators and the Environment*" (OECD, 2004d) recommended that OECD countries could develop the following indicators, in addition to those included in Chapter 1:

Environmental farm management plans

- Number (area) and share of farms (agricultural land area) under environmental farm management plans.

Nutrient management

- Number and share of farms (agricultural land area) using nutrient balances.

Pest management

- Number and share (agricultural land area) of farms with appropriate storage/handling/cleaning and disposal facilities for treatment of pesticide wastes (*i.e.* packaging and unused pesticides).

Soil management

- Number and share of farms where soil biophysical properties are monitored as part of the soil test programme and/or used as land management decision support tool.

Water management

1. Area and share of agricultural land that is drained.
2. Area and share of drained land under different forms of drainage technology (*e.g.* surface, subsurface, controlled).

Landscape management

- Number (area) and share of farms (agricultural land area) under public and private schemes committed to natural and cultural landscape maintenance and enhancement.

Farm management capacity

1. Number and share of farmers participating in agri-environmental education programmes.
2. Expenditures on agri-environmental management research and extension as a share of total agricultural budgetary expenditures on research and extension.

Assessment. The range of farm management indicators (FMIs) need to reflect the complexity and diversity of agricultural systems, with reliable data derived from spatially and temporally appropriate levels. The obstacle in developing FMIs is that much national census and survey data are of poor quality as the most appropriate unit of measurement may often be at the individual farm level. Key aspects of these indicators are their complementarities with all other indicators. The interactions between farm management systems, policies and environmental outcomes are not well developed, while identifying suitable data sets and better co-ordination of data collection methods are also needed.

Methods to integrate social factors (*e.g.* agri-environmental education) in the design of these indicators are needed if farm management indicators are to be better integrated into policy and projection models, and be more effectively used in evaluating the economic and environmental costs of changes in farming practice. One example of this is farmer education. Some countries have developed indicators to reveal the extent to which farmers have participated in agri-environmental education programmes in the early 2000s (Figure 2.11; EEA, 2005).

2.3. Overall assessment

This section provides an overall assessment of the common themes that emerge from the review of indicators listed in this chapter, supported by background information in Annex 2.A2. The assessment is intended to identify the areas of research that could be strengthened if they are to make a contribution to providing policy makers with analytical and monitoring tools on the impact of agriculture on the environment.

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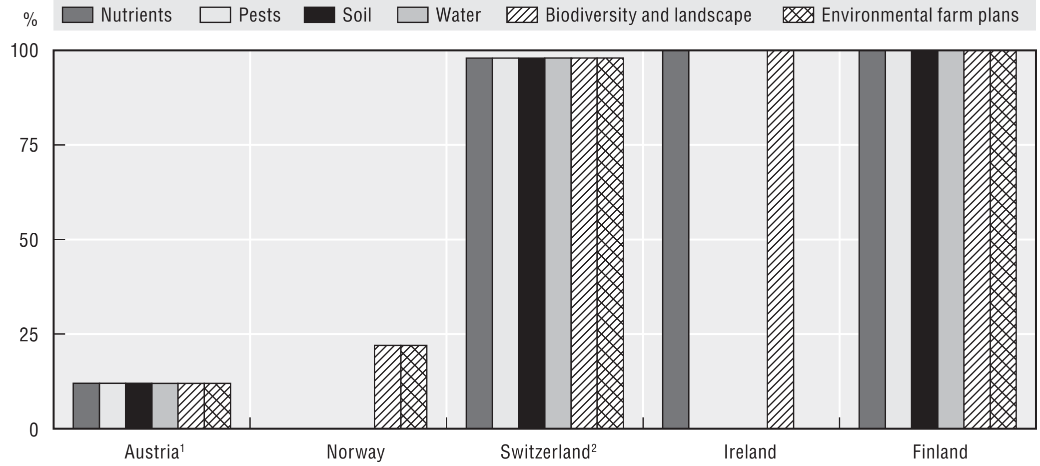
Figure 2.11. **Share of farmers participating in agri-environmental education programmes**

Early 2000s



StatLink http://dx.doi.org/10.1787/288662011751

1. Estimated data for 2000-02.
2. The share is 98% for all categories.

Source: OECD (2005).

OECD has identified a number of general criteria which agri-environmental indicators need to meet, including that indicators should be (OECD, 2001):

- ***policy relevant*** – address the key environmental issues faced by governments and other stakeholders in the agriculture sector;
- ***analytically sound*** – based on sound science, but recognising that their development involves successive stages of improvement;
- ***measurable*** – feasible in terms of current or planned data availability and cost effective in terms of data collection; and
- ***easy to interpret*** – communicate essential information to policy makers and the wider public in a way that is unambiguous and easy to understand.

Policy relevant: The indicators covered in this chapter could be broadly divided into two main groups in terms of their policy relevance across OECD countries. ***First***, those AEIs that are of policy relevance across most OECD countries, although as yet neither the methodology nor the data are sufficiently advanced to develop comprehensive cross country time series indicators. This group covers indicators of: soil erosion, soil organic carbon and soil biodiversity (Section 2.2.1); water use and water quality (Section 2.2.2); biodiversity (Section 2.2.3); and farm management (Section 2.2.5). The ***second*** group of indicators are of policy relevance to a smaller group of countries and cover the indicators related to landscape and land ecosystem functions (Section 2.2.4). Annex 2.A2 identifies the extent to which countries are developing quantitative and/or qualitative information for the indicators examined in this chapter, based on member country replies to the OECD agri-environmental questionnaire.

Analytically sound: Although indicators should provide an accurate and scientifically rigorous reflection of the actual situation, it is sometimes a difficult task in developing certain types of indicators. For example, in the case of farm management indicators, the links between farming activities and biodiversity are complex and not fully understood.

This is also an issue in the case of soil biodiversity and environmental farm management practices, where the lack of consistent methodologies as well as the underlying data are major obstacles in developing these indicators. The degree to which the indicators are analytically sound across OECD countries (from high to poor) is identified in Annex 2.A2, but it should be emphasised that for some indicators this is variable. For example, the habitat-species matrix analytical methodology is well developed in Canada but other countries are beginning to explore the possibilities of how such a matrix could be developed for their country.

Overall, the Expert Meetings identified the following needs to strengthen the analytical basis of AEIs: developing scientific and socio-economic knowledge underlying AEIs; improving consistency and transparency in methods used to collect, process and interpret data; reporting indicators at a spatially appropriate level, in order to provide effective analysis and in order to discover "false" relationships, which will also include the better integration of data from local to national data sets; and ensuring that social factors (*i.e.* human and community development) are better integrated into analysis of agri-environmental outcomes.

Measurable: The collection of appropriate data available across regional as well as national boundaries involves the development and widespread adoption of appropriate data collection methods. This may include survey techniques, such as questionnaires; distribution of standardised spreadsheets for data collection; and co-operation with other international organisations that have developed databases for the relevant indicator areas. This not only concerns the quantity and quality of data collected, but also reflects the methodologies used to derive the indicators. In many of the OECD Expert Meetings, it was argued that individual OECD country approaches should strive for greater uniformity of data used across countries. Reinforcing this view, the work on some of farm management indicators shows that available data are often of poor quality, and that measurability requires reliable data that are derived from spatially and temporally appropriate levels. Annex 2.A2 shows for the countries that have replied to the OECD questionnaire whether data is already regularly collected to measure the indicator or at the other extreme if data collection systems for the indicator are still under construction.

Overall, the Expert Meetings identified the following needs to strengthen the measurability of AEIs: identifying suitable data sets, collected through surveys and census; taking into account the different degree of uncertainties among indicators when presenting data and indicator outputs to encourage appropriate use of the information; and seeking more intensive verification of data to ensure accuracy.

Easy to interpret: Indicators need to be as unambiguous as possible so that it is clear what the data and trends mean. This is particularly important for some types of indicators, such as the agri-biodiversity area as comprehensive knowledge about the interactions between farming activities and biodiversity is not yet fully developed (Section 1.8, Chapter 1; OECD, 2003c). A similar issue can be seen in the soil-biodiversity area where in the Expert Meeting, experts noticed that a particular challenge for this indicator area is to identify interpretable indicators (OECD, 2003a). Although Annex 2.A2 attempts to identify from the indicators that exist across countries to what extent they are easily interpreted (from very easy to poor) this task is difficult especially for many of these indicators which are still at an early development stage.

Overall the Expert Meetings identified the following needs to strengthen the ease of interpreting AEIs: improving knowledge (analysis) of the cause and effect relationships between agricultural systems, policies and environmental outcomes, to better serve the needs of decisions makers, including individual farmers, the farming and agro-food industry, governments and other stakeholders (*e.g.* environmentalists and consumers); and developing methods that can better integrate improved indicators into policy and projection models.

Finally, the importance of national and international agencies concerned with developing and collecting data to calculate agri-environmental indicators was stressed at the OECD Expert Meetings in terms of:

1. improving co-ordination of data collection techniques and efforts within OECD countries and between international agencies, taking into account farmer survey and census fatigue, and the costs of data collection;
2. encouraging OECD countries to invest more in agri-environmental education and promotion of awareness of those who provide data (the farmers) and those who process and interpret data (the policy makers and evaluators both at the national and international level);
3. considering the costs of collecting the primary data to calculate indicators; and,
4. fostering receptive conditions for the use of indicators by decision makers at all levels, from the farm to the international level.

ANNEX 2.A1

*Agri-environmental Indicators of Regional Importance and/or under Development**

Theme	Indicator title	Indicator definition (trends over time for all indicators)
I. Soil	***i.* Soil erosion**	1. Area and share of agricultural land affected by tillage erosion in terms of different classes of erosion, *i.e.* tolerable, low, moderate, high and severe.
		2. Contribution (as a share or physical quantity) of agriculture to off-farm sediment flows into the landscape and water bodies (from water, wind and other erosion sources).
		3. Gross on-farm soil erosion, measured through integrating models of wind, water and tillage erosion.
		4. On-farm and off-farm economic costs from soil erosion.
	***ii.* Soil organic carbon**	5. Total soil organic carbon in agricultural land.
II. Water	***iii.* Water use**	6. A net agricultural groundwater balance, where information is available, to take into account both agricultural withdrawals and recharge of groundwater.
		7. The annual share of rivers/lakes where agricultural water extraction results in rivers/lakes falling below a (seasonal) minimum reference level.
		8. The impact of agricultural water use on ecosystem health (*e.g.* wild species and wetlands).
		9. Average value of irrigated agricultural product(s) per unit of irrigation water consumed (or alternatively water withdrawn or licensed water allocation, where the water withdrawn could be the *gross* value of total water withdrawn or the *net* value of total water withdrawn minus the value of water returned to rivers and lakes and recharged to groundwater).
		10. Charges for water supplies to farmers relative to water supply charges for other major users (industry and urban).
	***iv.* Water quality**	11. Salt concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas.
		12. Pathogen (faecal indicator or pathogenic bacteria) concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas.
		13. Share of pathogen contamination derived from agriculture in surface waters and groundwater.
III. Climate change	***v.* Greenhouse[1] gases**	14. Net agricultural greenhouse gas emission balance (*i.e.* emissions less sinks).
IV. Biodiversity	***vi.* Genetic resource diversity**	15. Number and share of national native crop varieties (*i.e.* cereals, oil crops, root crops, fruit and vegetables) that are considered to be at risk of extinction (*i.e.* critical or endangered risk status).
	***vii.* Wild species diversity**	16. Number of ecologically indicative wild species using agricultural land.

* All of the indicators listed in this annex are those for which either methodologies and/or data sets are not yet at a stage that allows for representative comparative OECD country coverage or in certain cases (*e.g.* cultural landscape indicators and water retaining capacity) are only policy-relevant to some OECD countries, as shown in this chapter.

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Theme	Indicator title	Indicator definition (trends over time for all indicators)
	***viii.* Ecosystem (habitat) diversity**	17. Quality and quantity of habitat features (*e.g.* patch size, linear features and networks,) and their spatial composition (*e.g.* fragmentation, vertical structures, mosaics) across agricultural land.
	***ix.* Linkages between habitats and species**	18. *Habitat-Species Matrix*, linking changes in the area and management of all agricultural habitat types on wild species (flora and fauna) through data from either explicit field observation or indirect information (*e.g.* expert knowledge).
		19. *Natural Capital Index*, the product of the quantity of agricultural habitat types and their quality in terms of wild species abundance, richness, habitat structure and management, measured between the current state of the agro-ecosystem and a baseline state.
V. Landscape and land ecosystem functions	***x.* Landscape**	20. Landscape Structure: land use, cover, patterns and cultural features (*e.g.* hedges and historic farm buildings).
		21. Landscape Functions: recreation (*e.g.* accessibility; cultural identity, tranquillity, and ecosystems (see biodiversity).
		22. Landscape Values: monetary value of agricultural landscapes (*e.g.* calculated through methods such as contingent valuation).
	***xi.* Land ecosystem functions**	23. Water retaining capacity, quantity of water that can be retained in the short term, in agricultural soil, as well as on agricultural land where applicable (*e.g.* flood storage basins) and by agricultural irrigation or drainage facilities.
		24. Water retaining capacity by agricultural irrigation or drainage facility, to reveal extent to which on-farm water storage facilities retain water (*e.g.* on farm dams, dykes, canals, etc.).
		25. Landslide mitigation index, proportion of managed agricultural land within the agricultural land area subject to landslide risk.
VI. Farm management	***xii.* Environmental farm management plans**	26. Number (area) and share of farms (agricultural land area) under environmental farm management plans.
	***xiii.* Nutrient management**	27. Number and share of farms (agricultural land area) using nutrient balances.
	***xiv.* Pest management**	28. Number and share (agricultural land area) of farms with appropriate storage/handling/cleaning and disposal facilities for treatment of pesticide wastes (*i.e.* packaging and unused pesticides).
	***xv.* Soil management**	29. Number and share of farms where soil biophysical properties are monitored as part of the soil test programme and/or used as land management decision support tool.
	***xvi.* Water management**	30. Area and share of agricultural land that is drained.
	***xvii.* Landscape management**	31. Number (area) and share of farms (agricultural land area) under public and private schemes committed to natural and cultural landscape maintenance and enhancement.
	***xviii.* Farm management capacity**	32. Number and share of farmers participating in agri-environmental education programmes.
		33. Expenditure on agri-environmental management research and extension as share of total agricultural budgetary expenditures on research and extension.
VII. Agricultural inputs	***xix.* Energy**[2]	34. Total amount of energy contained in key agricultural inputs.
		35. The energy efficiency of agricultural production is the monetary value of annual agricultural production per unit of energy directly consumed by agriculture to produce that annual agricultural production.
		36. Production and use of renewable energy by agriculture.

1. See Box 1.7.1, Section 1.7.3, Chapter 1.
2. See Section 1.4, Chapter 1.

Source: OECD (2007).

ANNEX 2.A2

A Qualitative Assessment of the Agri-environmental Indicators included in Annex 2.A1 according to the OECD Indicator Criteria

Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
***i.* Soil erosion** 1. Area and share of agricultural land affected by tillage erosion	+++	++	+	++	Soil erosion and soil biodiversity (OECD, 2003a)	Belgium, Canada, Norway, Switzerland, United Kingdom	+++
2. Contribution of agriculture to off-farm sediment flows	+++	+	+	+		Belgium, Czech Republic, Greece, Norway, Switzerland	+++
3. Gross on-farm soil erosion, measured through integrating models of wind, water and tillage erosion	++	+	+	+		Netherlands, Switzerland, United States	+
4. On-farm and off-farm economic costs from soil erosion	+++	++	+	+++		United States	+++
***ii.* Soil organic carbon** 5. Change in total soil organic carbon in agricultural land over time	+++	+	+	+++	Soil organic carbon (OECD, 2003b)	Belgium, Canada, Finland, France, Ireland, New Zealand, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States	+++
***iii.* Water use** 6. A net agricultural groundwater balance, where information is available, to take into account both agricultural withdrawals and recharge of groundwater					Water use and water quality (OECD, 2004b)		
7. The annual share of rivers/lakes below a minimum reference level	+++	+	+	+++		Japan, United Kingdom	++
8. The impact of agricultural water use on ecosystem health	+++	+	+	+		Japan, Korea, United Kingdom, United States	+

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Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
9. Trend in the average value of irrigated agricultural product(s) per unit of irrigation water consumed	++	+	+	+		Korea, Netherlands, United States	+++
10. Charges for water supplies to farmers relative to water supply charges for other major users (industry and urban)	+++	++	++	++		Australia, Austria, Canada, Finland, France, Greece, Hungary, Korea, Netherlands, Portugal, Slovak Republic, Spain, Turkey, United Kingdom	+++
***iv.* Water quality** 11. Salt concentrations in surface waters and groundwater in excess of national water threshold values	+++	++	+	+++	Water use and water quality (OECD, 2004b)	France, Greece, Netherlands, Slovak Republic, Turkey	+++
12. Pathogen concentrations in surface waters and groundwater in excess of national water threshold values in representative agricultural areas	+++	++	+	+++		Denmark, Finland, France, Ireland, Korea, Netherlands, New Zealand, Norway, Switzerland	+++
13. Share of pathogen contamination derived from agriculture in surface waters and groundwater	+++	++	+	+++		Canada, Denmark, Ireland, Netherlands, Switzerland	++
***v.* Greenhouse gases** 14. Net agricultural greenhouse gas emission balance	+++	+	+	+++	No expert meeting or questionnaire response	Canada, Switzerland	+++
***vi.* Genetic resource diversity** 15. Number and share of national native crop varieties that are considered to be at risk of extinction	+++	++	+	++	Biodiversity (OECD, 2003c)	Austria, Luxembourg, Slovak Republic, Switzerland	++
***vii.* Wild species diversity** 16. Number of ecologically indicative wild species using agricultural land	++	+	+	++	Biodiversity (OECD, 2003c)	Canada, Czech Republic, Denmark, Finland, Korea, Netherlands, Switzerland	+

Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
***viii.* Ecosystem (habitat) diversity** 17. Quality and quantity of habitat features and their spatial composition across agricultural land	++	++	+	++	Biodiversity (OECD, 2003c)	Denmark, Finland, Germany, Greece, Italy, France, Japan, Korea, Netherlands, Norway, Portugal, Sweden, Switzerland, United Kingdom	+
***ix.* Linkages between habitats and species** 18. Habitat – species matrix	+++	+	+	++	Biodiversity (OECD, 2003c)	Canada, Finland	+++
19. Natural capital index	++	++	+	+		Netherlands	+++
***x.* Landscape** 20. Landscape structure	+++	+	+	++	Landscape (OECD, 2003d)	Denmark, Finland, France, Germany, Greece, Italy, Japan, Korea, Netherlands, Norway, New Zealand, Portugal, Sweden, Switzerland, United Kingdom	
21. Landscape functions	++	+	+	+		Denmark, Finland, Korea, Netherlands, Switzerland	+
22. Landscape values	++	+	+	++		Denmark, Finland, France, Greece, Japan, Korea, Netherlands	++
***xi.* Land ecosystem functions** 23. Water retaining capacity (WRC)	++	++	+	++	Land conservation (OECD, 2004c)	Greece, Italy, Japan, Korea	++
24. Water retaining capacity by agricultural irrigation or drainage facility (WF)	++	++	++	++		Greece, Italy, Japan, Korea, Slovak Republic, United Kingdom	++
25. Landslide mitigation index (LMI)	++	+	+	++		Hungary, Japan	++

Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
***xii.* Environmental farm management plans** 26. Number (area) and share of farms (agricultural land area) under environmental farm management plans	+++	+++	++	+++	Farm management (OECD, 2004d)	Austria, Belgium, Canada, Czech Republic, Finland, Germany, Hungary, Ireland, Japan, Korea, Netherlands, New Zealand, Norway, Slovak Republic., Switzerland, United Kingdom	++
***xiii.* Nutrient management** 27. Number and share of farms (agricultural land area) using nutrient budgets	+++	+++	+	+++	Farm management (OECD, 2004d)	Ireland, Japan, New Zealand, Norway, Switzerland	+++
***xiv.* Pest management** 28. Number and share (agricultural land area) of farms with appropriate storage/handling/cleaning and disposal facilities for treatment of pesticide wastes	+++	+	+	++	Farm management (OECD, 2004d)	Belgium, Finland, Norway, New Zealand, Switzerland	++
***xv.* Soil management** 29. Number and share of farms where soil biophysical properties are monitored as part of the soil test programme and/or used as land management decision support tool	++	+	+	+	Farm management (OECD, 2004d)	Austria, New Zealand, Switzerland	+
***xvi.* Water management** 30. Area and share of agricultural land that is drained	+	+	+	+	Farm management (OECD, 2004d)	Belgium, Czech Republic, Finland, Germany, Greece, Hungary, Netherlands, Norway, Slovak Republic, Turkey	++
***xvii.* Landscape management** 31. Number (area) and share of farms (agricultural land area) under public and private schemes committed to natural and cultural landscape maintenance and enhancement	++	++	++	++	Farm management (OECD, 2004d)	Austria, Belgium, Korea, Netherlands, Norway, Switzerland, United Kingdom	+++
***xviii.* Farm management capacity** 32. Number and share of farmers participating in agri-environmental education programmes	++	+	+	++	Farm management (OECD, 2004d)	Austria, Finland, Ireland, Norway, Switzerland	++

Indicator definition[1]	General criteria[2]				Expert meeting[3]	Countries[4]	
	Policy relevant	Analytically sound	Measurable	Easy to interpret		Coverage	Comparability
33. Expenditure on agri-environmental management research and extension as share of total agricultural budgetary expenditures on research and extension	++	+	+	++		Korea, Norway, Sweden	+++
***xix.* Energy**[5] 34. Trends in the total amount of energy contained in key agricultural inputs	+	+	+	+		Switzerland	++
35. The energy efficiency of agricultural production is the physical (monetary) value of annual agricultural production per unit of energy directly consumed by agriculture to produce that annual agricultural production	++	+	+	++		Canada, Switzerland	++
36. Production and use of renewable energy by agriculture	+++	+++	++	+++		Many OECD countries	+++

The notation for each criterion is as follows: +++ = very good/strong; ++ = average; + = poor.

1. For a full definition of each indicator see Annex 2.A1.
2. For a discussion of each criterion see Section 2.3 of this chapter.
3. This column indicates at which OECD Agri-environmental Indicator Expert Meeting the indicator was discussed. see Bibliography for a list of these meetings.
4. This column shows which countries are developing the indicator, quantitatively and /or qualitatively, based on member country replies to the unpublished OECD Agri-environmental Indicator questionnaires The column also reveals the extent to which the indicator is comparable across countries.
5. Energy indicators are from an unpublished OECD consultant's paper.

Source: OECD (2007).

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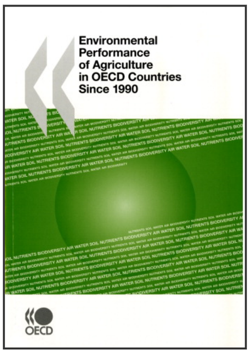

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