ENVIRONMENTAL IMPACTS IN THE AGRICULTURAL SECTOR: USING INDICATORS AS A TOOL FOR POLICY PURPOSES

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ENVIRONMENTAL IMPACTS IN THE AGRICULTURAL SECTOR: USING INDICATORS AS A TOOL FOR POLICY PURPOSES

Kevin Parris, OECD

EXECUTIVE SUMMARY

Agriculture plays a small part in the economies of NAFTA countries, contributing between 1-2% of GDP and 3% of employment, although these shares are larger in Mexico. But in terms of its impact on the environment and natural resources, agriculture's role is more significant accounting for 45% of total land use and 40% of water use, except in Canada where these shares are lower.

As well as producing food and fibre, agriculture is also increasingly being required to provide various environmental services, such as habitat for wildlife; providing ecological services, for example, acting as a sink for greenhouse gases; and supplying amenities, like attractive landscapes. There are concerns, however, that the scale of agricultural expansion is going to place greater pressure on the environment over the coming decades if it is to meet the 1.5 billion growth in the global population expected by 2020.

Some consider that current farming practices are leading to the degradation and depletion of the natural resource base upon which farming depends, namely soils, water, natural plant and animal resources. Also there are fears that agriculture may be reaching certain biophysical limits in trying to further raise crop and livestock yields. There are broader concerns about the negative external impacts of agricultural in terms of harmful emissions into the environment.

It is against this background that this paper sets out to answer five questions:

1. Why is OECD developing a set of agri-environmental indicators?

2. What are the strengthens and limitations of agri-environmental indicators?

3. What are the recent trends in the environmental performance of agriculture in NAFTA countries?

4. How are agri-environmental indicators being used as a tool to inform policy makers?

5. What are the future challenges to improve the environmental assessment of agriculture for policy purposes?

In responding to the fourth question – "How are agri-environmental indicators being used as a tool to inform policy makers? – the paper examines three case studies as illustrations of the use of indicators in policy analysis, including:

1. agriculture's impact on soil resources in NAFTA countries;

2. the domestic consequences for NAFTA and other OECD countries of agricultural trade liberalisation's impact on nitrogen pollution from livestock; and the,

3. projection to 2020 of greenhouse gas emissions from agriculture in NAFTA and other OECD countries.

ENVIRONMENTAL IMPACTS IN THE AGRICULTURAL SECTOR: USING INDICATORS AS A TOOL FOR POLICY PURPOSES

"New indicators of progress are needed to monitor the economy, wherein the natural world and human well-being, not just economic production, are awarded full measure." Edward. O. Wilson, *Consilience - The Unity of Knowledge*, p.326, Little Brown and Company, United States, 1998.

"….it would be especially useful to develop better data quantifying the losses of natural capital we currently are experiencing." Kenneth Arrow, *et al*, *Are We Consuming Too Much?*, p.19, 9 July, 2001 Draft from the United States Hewlett Foundation Research Initiative on the Environment, the Economy and Sustainable Welfare, unpublished.

1. Why is OECD Developing a Set of Agri-Environmental Indicators?

The key role of agriculture now and in the future is the supply of an adequate and safe supply of food at 'reasonable' prices. Over the past 40 years while world population has nearly doubled, food prices have dropped substantially in real terms and food production per capita has increased by nearly 25%.

These developments have been made possible through farmers, scientists and public and private agricultural research investment raising crop yields and livestock productivity and improving farm management practices. The productivity improvements for agriculture have also been achieved through using less labour, purchased inputs and land.

There are concerns, however, that the scale of agricultural expansion is going to place greater pressure on the environment over the coming decades if it is to meet the 1.5 billion growth in the global population expected by 2020. Some consider that current farming practices are leading to the degradation and depletion of the natural resource base upon which farming depends, namely soils, water, natural plant and animal resources.

But others see agriculture launching into a new era of expansion and growth through the 21st century. This scenario sees a continuation of improvements in farm management practices, advances in biotechnology and the revolution in information and communication technologies. Also the process of trade liberalisation and globalisation of the agro-food chain will provide the basis for the investment and continued future growth of agriculture on an environmentally sustainable path.

Understanding the environmental impacts of agriculture requires information on the relationship between agriculture, the environment, trade and sustainable development. Recent OECD meetings of agriculture and environment ministers have emphasised the importance of examining agricultural and environmental policy issues supported by indicators and better information.

Against this background OECD has since 1995 (see OECD 1997; 1999a; and 2001a), been developing a set of agri-environmental indicators, listed in Annex 1, which aim to provide:

- information of changes in environmental conditions in agriculture; and,
- a tool to help policy makers and other stakeholders in the monitoring and evaluation of the impacts of policies on environmental conditions in agriculture and in future looking scenarios, to improve policy effectiveness in promoting sustainable agriculture.

2. What are the Strengthens and Limitations of Agri-Environmental Indicators?

In examining the strengthens and limitations of using agri-environmental indicators (AEIs) to assess the environmental performance of agriculture, they should be considered in the context of other well established economic and social indicators for three reasons:

1. It is only relatively recently that work in OECD countries has started on establishing AEIs and associated data collection efforts. Inevitably the process of development is iterative as indicators are tried and tested by users until a consensus forms around a core set, as has occurred over the much longer historical record of developing, for example, economic performance indicators, such as measures of inflation and gross domestic product.

2. To capture through indicators the interface between the biophysical "natural" environment and agricultural activities is often more complex and difficult than monitoring trends in purely economic (e.g. incomes) and social (e.g. education) activities. Also some agri-environmental outputs and effects are not valued in conventional markets and have no monetary values (e.g. biodiversity) nor are easily measured physically (e.g. the carbon sink function of soils).

3. Many of the issues related to the limitations of interpreting AEIs, apply equally to other indicators. With many economic and social variables, for example, there can be a wide regional variation around national averages (e.g. employment levels), and definitional, methodological and data deficiency issues are not uncommon (e.g. the measurement of poverty and wealth distribution).

While some OECD countries have begun the process of using indicators for policy purposes and also that the OECD is increasingly using AEIs in various studies and activities for policy purposes and projection studies (Annex 2); there remain a number of challenges to help overcome the current limitations and build on the strengthens of the existing set of OECD and Member country AEIs.

Calculation methodologies for indicators are at varying stages of development, with work on some areas having a longer history of research, such as nutrient use and soil quality, while for other areas, such as biodiversity, quantification is at an earlier stage of development. There is also a lack of knowledge about causalities and linkages between indicators in some cases. For example, explaining the causes of changes in wild species distribution and populations on farm land is complex as it can relate to changes in farming practices and factors, such as the influence of climate or alteration to other habitats in proximity to agriculture, for example, forests and aquatic ecosystems.

Data deficiencies are also an impediment to indicator development, including issues related to incomplete data series, poor quality and non-validated data, and in some cases no systematic collection of data to calculate indicators. But many countries are beginning to make progress in overcoming data deficiencies. This progress is being facilitated by drawing on existing data, extending their use through using new information technologies, and also improving the co-operation and co-ordination between different national and international agencies developing indicators.

To eliminate some of the methodological and data impediments current AEIs requires further attention to spatial and temporal considerations, and use of benchmarks against which to assess performance. Also, where possible, moving from physical to a common unit of measure, such as money or energy, to help examine various questions related to linkages and trade–offs, such as the trade–offs between changes in agricultural production, farm input use and environmental outcomes.

National averages can mask the ***spatial variance*** of an indicator, and to overcome this limitation it is important to reveal the variation around the national average, such as the percentage of the total agricultural land area experiencing low, moderate or high soil erosion rates. Statistical measures might also be used to more accurately determine the significance of variation around national averages. Developing and measuring indicators for a range of spatial scales, however, can be constrained by the ability to extrapolate data from the field/farm level to higher levels and the trade–offs that occur with gains in coverage at higher levels but loss of detail and variation at lower scales.

Temporal variation of the different environmental effects of agriculture vary greatly, such as nutrient and pesticide run-off from agricultural land into rivers which can occur rapidly (hours/days), but over longer periods into groundwater (months/years). Moreover, understanding the impacts of farming on the environment over time can be difficult because of their complexity, such as the links between greenhouse gas emissions and climate change; their irreversibility, e.g. removal of tropical rainforests, wetlands; their unexpected consequences, e.g. the effects of using DDT pesticide on wildlife; and sometimes due to the rapid change in environmental conditions, such as from floods. As a key focus of sustainable agriculture and development is the intergenerational impact, developing forward-looking AEIs will require further research and analysis.

The contribution of agriculture to specific environmental impacts is sometimes difficult to identify, especially for water quality, soil quality, and biodiversity, where other factors can play an important role. These factors may include, other economic activities (e.g. forestry, industry), the ‘natural’ state of the environment (e.g. water may contain high levels of naturally occurring salts, nitrates, organic components), and natural environmental processes (e.g. fires, floods, droughts).

Developing appropriate ***baselines, threshold levels and targets*** can be useful to help assess the performance of indicator trends. Some countries, for example The Netherlands, have established environmental targets by which to monitor and evaluate policy performance (OECD, 2000b). Given the difficulties in determining suitable benchmarks across countries, it may be more useful to track progress with indicators towards nationally agreed targets for different agri-environmental areas. Also trends and ranges in indicators can be 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. Tolerable rates of soil erosion, for example, can vary from 1-5 tonnes/hectare/year depending on site specific soil, topography and climatic conditions.

The use of a ***common indicator measure*** (e.g. money values) would allow for trends to be evaluated on a common basis. For policy purposes, it is necessary that agri-environmental information is provided in a form that enables policy makers to evaluate the performance of the sector, the effects of policies on environmental outcomes, and to weigh up the (marginal) changes in the environment with other outcomes (e.g. social, economic, agricultural production). While placing money values on environmental outputs and services has a role to play for policy purposes, especially in considering the trade–offs between economic, social and environmental demands in society, there still remains considerable constraints to estimating these values and trade–offs.

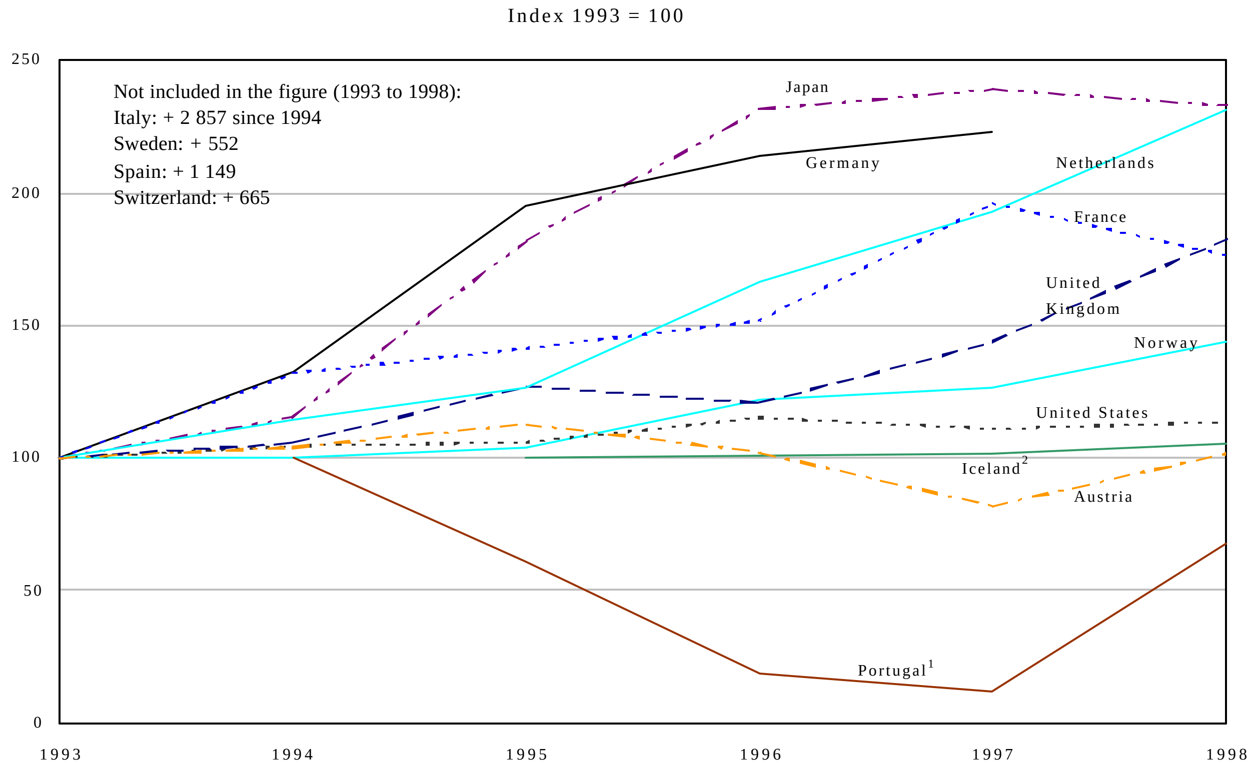
Developing ***linkages between different indicators*** can help contribute to a better understanding of underlying cause and effect relationships. For example, there are links between the price of water charged to farmers, the rate of expansion in irrigated area, the efficiency of water use management, and the impact of the use of water resources on aquatic environments and groundwater reserves. Also the interpretation of some indicators raise important trade-off questions. These cannot easily be interpreted without considering the indicators in a broader framework of assessment, such as determining the overall socio-economic and environmental costs and benefits associated with converting agricultural land to other uses, such as to forestry or for urban housing.

3. What are the Recent Trends in the Environmental Performance of Agriculture in NAFTA Countries? [1]

Agriculture plays only a small part in the NAFTA economies (Canada, Mexico and the United States), contributing about 1-2% of GDP and 3% of employment, except Mexico where the contribution of agriculture is larger, 6% and 19%, respectively. But in terms of the use of natural resources the role of agriculture in these countries is more significant, accounting for over 45% of total land use and more than 40% of water use, although in Canada these shares are only 8% respectively.

Many OECD countries have since the early 1990s introduced ***agri-environmental measures*** to help improve environmental performance, and NAFTA countries are no exception, responding with an array of measures that, in particular, have focused on changing farm management practices that are beneficial to the environment (Figure 1). In the United States, about 25% of total public agricultural research expenditure is directed toward agri-environmental concerns, and agricultural measures such as the US Conservation Reserve Program are helping to improve agri-environmental performance.

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



Notes:

1. 1994 = 100.

2. 1995 = 100.

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

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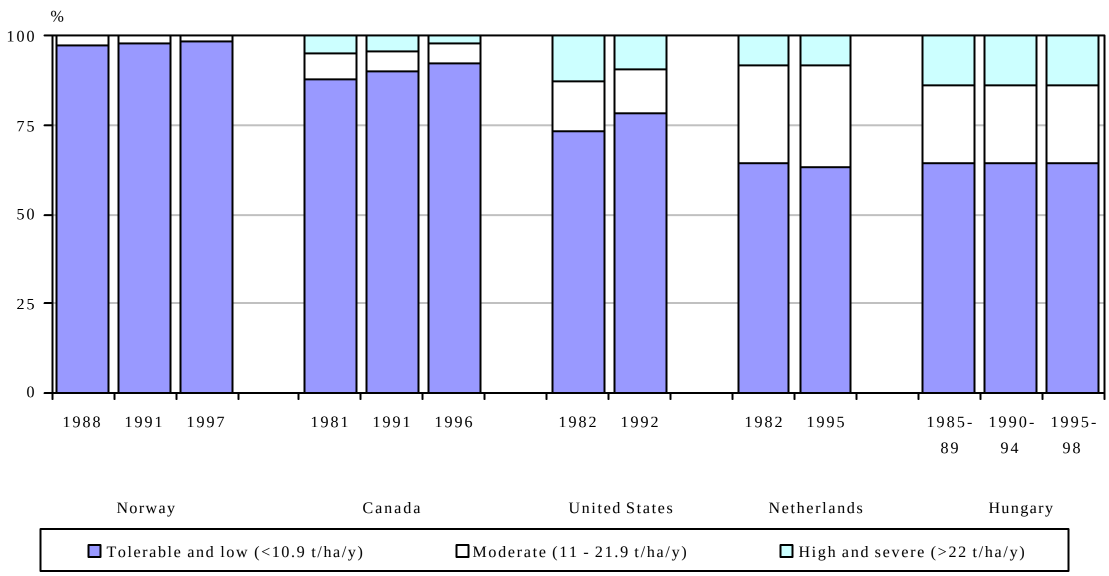
1. This section draws on the OECD (2001a) report. For a more detailed assessment of recent environmental impacts of agriculture using agri-environmental indicators, see in particular, for **Canada**, McRae, et al 2000; for the **United States**, USDA, 1997; and for **Mexico** visit the Mexico Ministry of Environment website, section on agricultural indicators, at: http://www.semarnat.gob.mx/estadisticas_ambientales/estadisticas_am_98/agricultura/

Damage to the ***quality of agricultural soils*** remains a major environmental issue in all NAFTA countries. In Canada almost 5 million hectares (or 7% of the total agricultural area) of marginal prairie land continues to be cultivated with a high risk of soil degradation, while in the US about one-third of total agricultural land continues to be subject to erosion rates which could impair the long-term productivity of the soil (Figure 2). Moreover, between 15-40% of agricultural land in Mexico is either totally or severely eroded. Soil erosion has been linked with off-farm costs in terms of losses of capacity in dams and reservoirs and reductions in the productivity of aquatic ecosystems. Even so, especially in Canada and the US, there have been significant gains in reducing threats to the productive capacity of agricultural land, in part because of land retirement, but also because of the adoption of soil conserving crop management practices such as conservation tillage.

Figure 2. **Agricultural land area affected by water erosion[1]: early 1980s to late 1990s**



Notes:

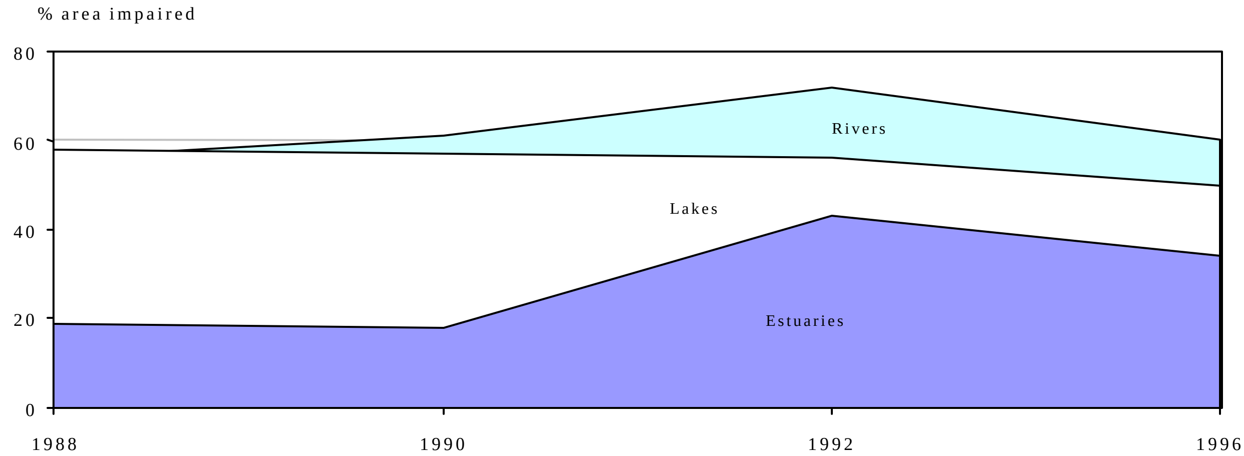
1. Some caution is required in interpreting this figure due to differences in the share of agricultural land assessed for erosion, which where: Norway: 100%, Canada: 54%, United States: 31%, Netherlands: 1%, and Hungary: 68-70%.

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

In the US agriculture is a major source of ***water pollution,*** accounting for most of the siltation, more than 80% of nitrogen and phosphates in surface water, and pesticides are detected in more than 80% of sampled rivers and fish in agricultural areas (Figure 3). The costs of agricultural water pollution in terms of treating drinking water, removing soil from rivers, reservoirs and lakes, and damage to aquatic species are known to be high. To reduce loadings of water pollutants from agriculture the government has introduced a programme of measures that cover technical and financial assistance and research, directed at agricultural non-point source pollution, and there are clear indications that overall agricultural water pollution has been improving since the introduction of the Clean Water Act in 1972.

While problems of water pollution in Canada and Mexico appear to be smaller than the US, nevertheless, some agricultural areas in Canada are at increasing risk to contamination from nutrients. This is mainly because of a shift to cropping patterns towards crops requiring higher levels of fertiliser, such as soyabeans and maize, and an increase in stocking densities with the intensification of livestock production in some regions of Canada.

Figure 3. **Share of agriculture in the impairment of surface and marine water quality: United States, 1988 to 1996**



Notes: 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.
Source: USDA, 1997

The marked increase in ***nitrogen surpluses*** since the mid-1980s in Canada and the US, is a further indication of the growing environmental risks associated with agricultural intensification, especially livestock, in some regions of these countries. Even so, the overall problem of nitrogen surpluses in North America is considerably lower, than that in the European Union (Figure 4).

Pesticide use in NAFTA countries has shown a small decrease in the US since the mid-1980s, although declined more sharply in Canada (Figure 5). The reduction in pesticide use is partly explained by a growing number of farmers using pest control methods that help limit the 'excessive' use of pesticides, with about two-thirds of farms using these pest control methods. The increase in the use of the *methyl bromide pesticide* in Mexico over the 1990s is of concern for the environment, as this pesticide acts as an ozone depleting substance (Figure 6). Canada, the US and most other OECD countries have been reducing their use of methyl bromide in accordance with their commitments under the Montreal Protocol on Substances that Deplete the Ozone Layer.

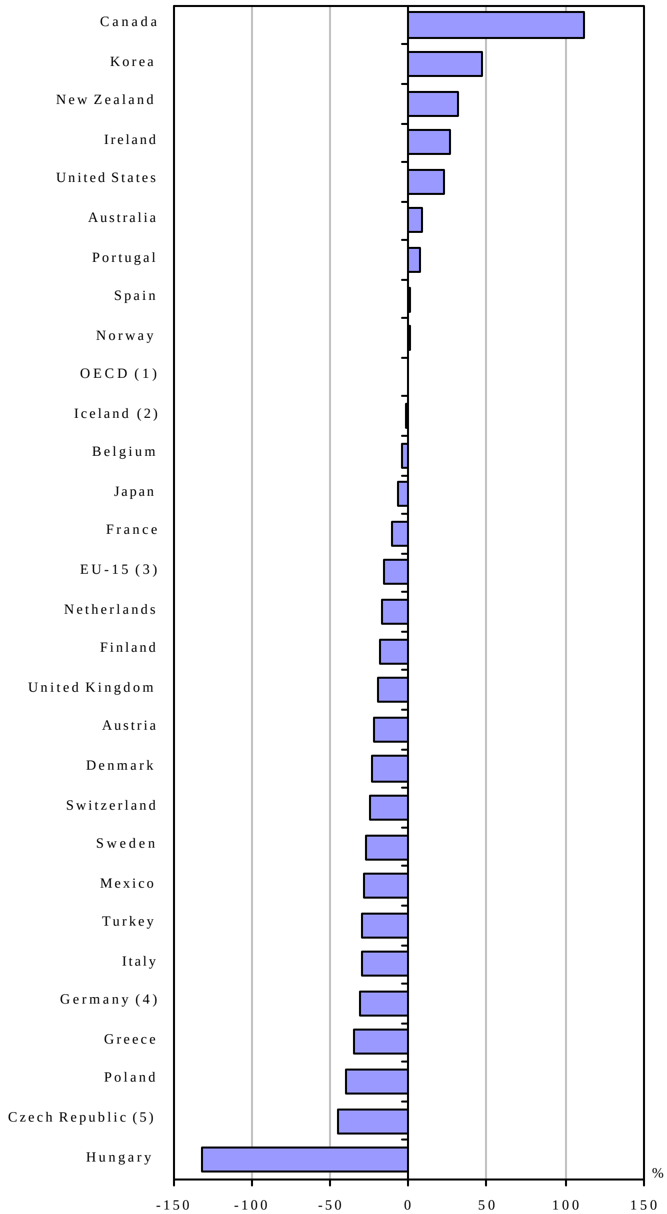
In common with many other OECD countries the ***price of water*** paid by NAFTA farmers is substantially lower than that paid by other industrial and household users (Figure 7). With the continuing expansion in irrigated agriculture and water use (Figure 8), in some areas across North America there is growing competition for scarce water resources with other users and greater stress on the water needs of aquatic habitats (e.g. wetlands, lakes). The Mexican National Water Commission has revealed that two-thirds of the water basins in Mexico are overexploiting available water resources, with over 80% of the country's water supply used without charge for agricultural irrigation, and an estimated 50% of this water likely wasted through inefficiencies in irrigation water management.

While subsidising agricultural water use and irrigation infrastructure mitigates against the more efficient use of water resources, NAFTA governments, are beginning to address the issue of making farmers pay more of the true costs of water services. Mexico is also in the process of developing technical assistance programmes to help improve irrigation management practices.

Figure 4. **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

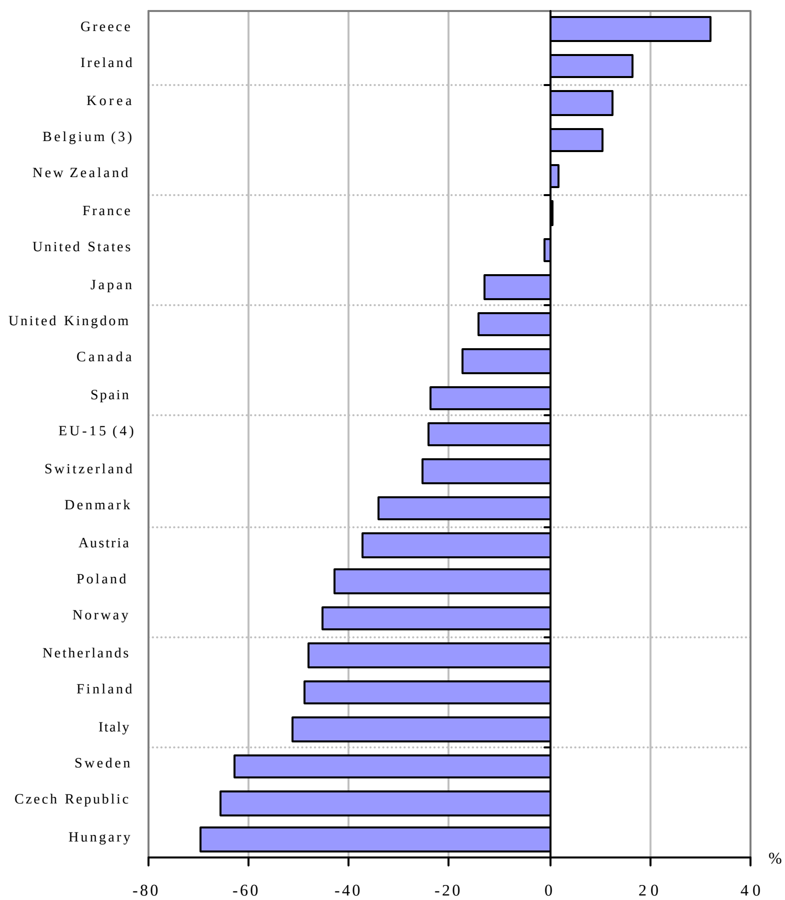
Notes: While these calculations have been derived from using an internationally harmonised methodology, nitrogen convers coefficients can differ between countries, which may be due to a variety of reasons. For example, differing agro-ecologi conditions, varying livestock weights/yield, and differences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

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

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

Figure 5. **Pesticide use in agriculture: 1985-87[1] to 1995-97[2]**

Change in tonnes of active ingredients



Tonnes of active ingredients[5]

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

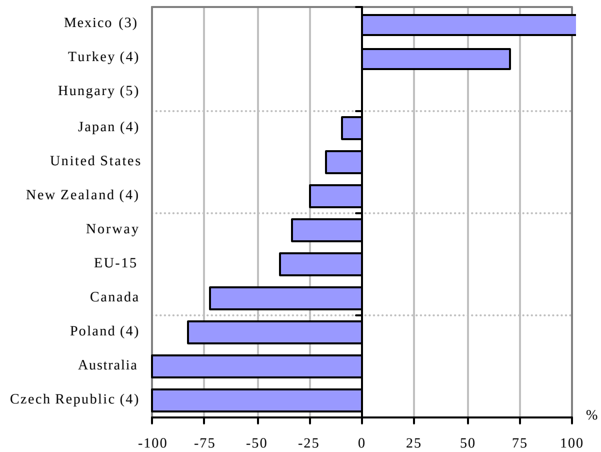
Notes: Some caution is required in comparing trends across countries because of differences in data definitions and coverage.

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

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

Figure 6. **Methyl bromide use[1]: 1991 to 1998**

Change in tonnes of ozone depleting substance equivalents (CFCs)[2]



Tonnes of ozone depletion potential

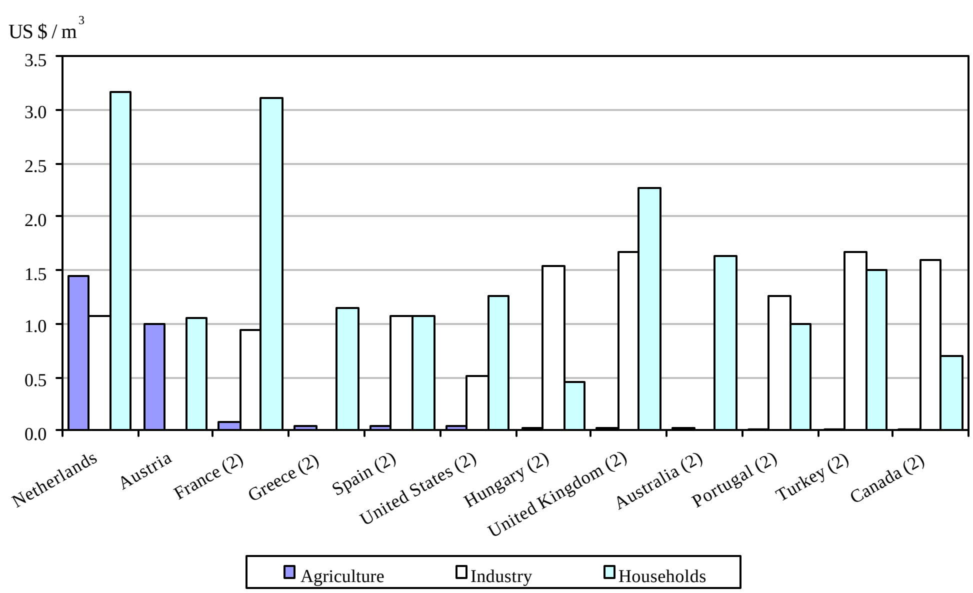
	1991	1998
Mexico	238	1 207
Turkey	296	504
Hungary	32	32
Japan	3 664	3 318
United States	15 317	12 649
New Zealand	81	61
Norway	6	4
EU-15	11 530	7 056
Canada	148	40
Poland	120	20
Australia	422	1
Czech Republic	6	0

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

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

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

Figure 7. **Comparison of agricultural, industrial, and household water prices [1]: late 1990s**



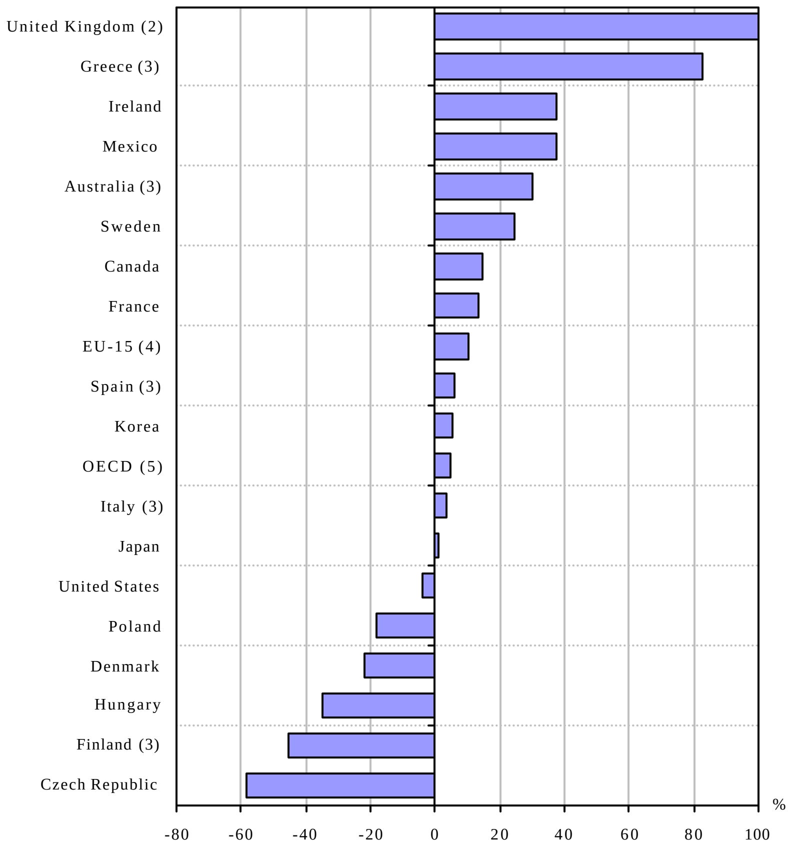
Notes: Some caution is required in comparing agricultural water prices with other user prices because water supplied to agriculture is usually of a lower quality than that provided to households and, on occasion, industry; while the capital costs of water conveyance systems are generally lower for agriculture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

1. For agriculture, industry, and households, prices are the median values for the range of prices for each category.
2. Agricultural water prices are less than 0.1 US $/m^3.

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

Figure 8. **Total agricultural water use[1]: early 1980s to mid / late 1990s**

Change in total agricultural water use



Agriculture water use
million m^3

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

Notes:

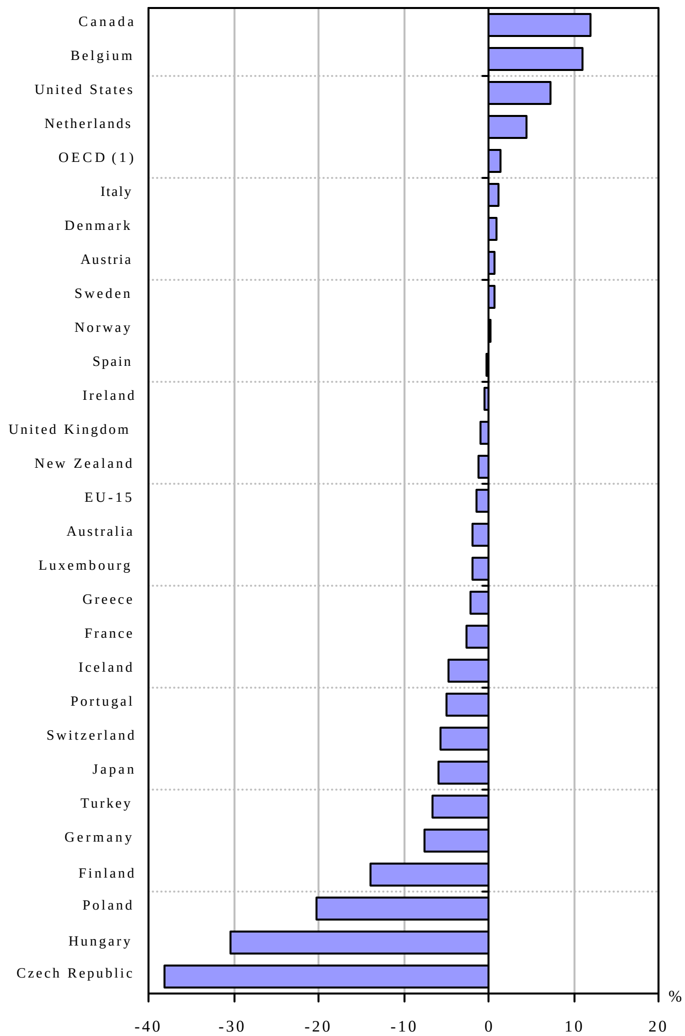
1. Agricultural water use includes water abstracted from surface and groundwater, and return flows (withdrawals) from irrigation for some countries, but excludes precipitation directly onto agricultural land.
2. England and Wales only. Percentage equals 124%.
3. Data for irrigation water use were used as data for agricultural water use are not available.
4. Austria, Belgium, Germany, Luxembourg, the Netherlands, and Portugal are excluded.
5. Austria, Belgium, Germany, Iceland, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Switzerland and Turkey are excluded.

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

Total national gross ***greenhouse gas emissions*** (GHG) from Canadian and US agriculture, over the period 1990 to 1997, showed large increases of over 7% compared to the OECD average of a 1% rise over the same period (Figure 9). The increase in GHG emissions are largely explained by expanding farm production, however, agriculture still only contributes about 7% and 10% of total Canadian and US GHG emissions, respectively. Agriculture also plays a role as a sink for GHGs, and with the improvements in tillage practices, and cover cropping and crop residue management in Canada and the US, this is improving the role of agricultural soils as a GHG sink.

Figure 9. **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

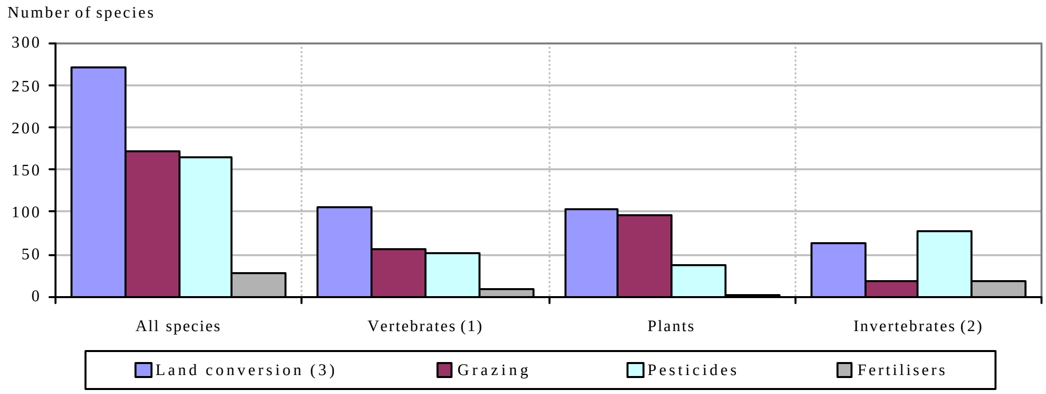
Notes:

1. Korea and Mexico are not included.

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

As agriculture is one of the major land-using activities for NAFTA countries its impact on ***biodiversity*** is significant. Agricultural activities in the US were estimated in 1995 to affect 380 of over 660 wild species listed as threatened or endangered (Figure 10). The main threats to wild species from agriculture originate from converting land to cropland and grazing, with exposure to farm chemicals also important. Several agricultural programmes include measures that are designed to reduce the conflict between agriculture and biodiversity loss, including the Conservation Reserve Program and the Wetlands Reserve Program. Wetland conservation, in particular, has been a key focus of policy debate over recent years in the US. The share of wetlands converted to agricultural use has been declining, and the US appears to be reaching its goal, set through various wetland conservation measures, of conserving and restoring at least as much wetland as is lost.

Figure 10**. Number of wild species threatened and endangered by the main sources of agricultural threats: United States, 1995**



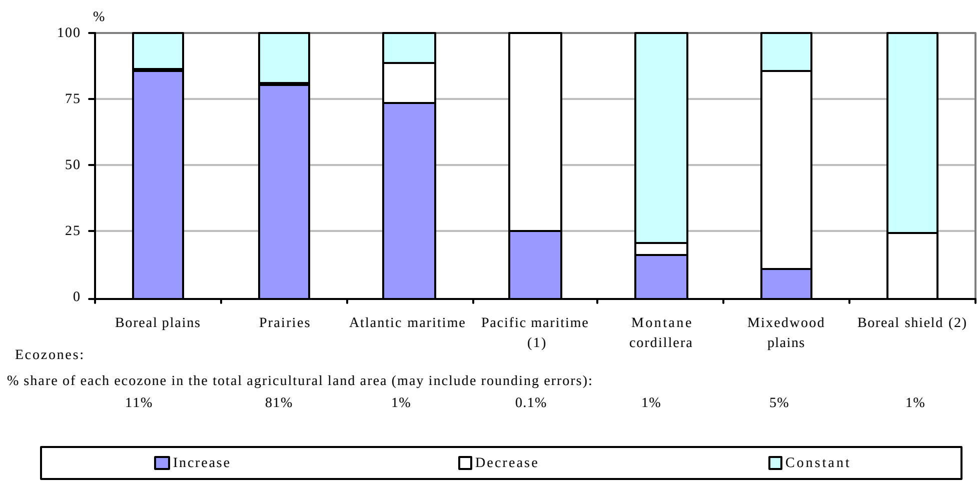
Notes:

1. Vertebrates: Amphibians, birds, fish, mammals and reptiles.
2. Invertebrates both on land and in aquatic ecosystems.
3. Conversion from non-agricultural land use to cropland.

Source: USDA (1997).

Changes in Canadian soil tillage and crop management practices are also beginning to have beneficial effects on wild species using agricultural land as habitat. Reductions in summer fallow and conversion of marginal cropland to other uses such as tame or seeded pasture are also likely to be of increasing benefit to wildlife and habitat conservation in Canada (Figure 11). A key driving force affecting the impact of agriculture on biodiversity in Mexico has been the increase in the total agricultural land area which expanded by over 6% from 1985 to 1997, compared to most other OECD countries, including Canada and the US, where the agricultural land area has been decreasing. However, there is at present no systematic assessment revealing the effects of the expansion in the area of agricultural land in Mexico on biodiversity, including wildlife habitat.

Figure 11. **Share of habitat use units for which habitat area increased, decreased and remained constant: Canada, 1981 to 1996**



Notes:

1. The share for which habitat area remained constant equals 0%.
2. The share for which habitat area increased equals 0%.

Source: Neave *et al.* (2000).

4. How are Agri-environmental Indicators being Used as a Tool to Inform Policy Makers?

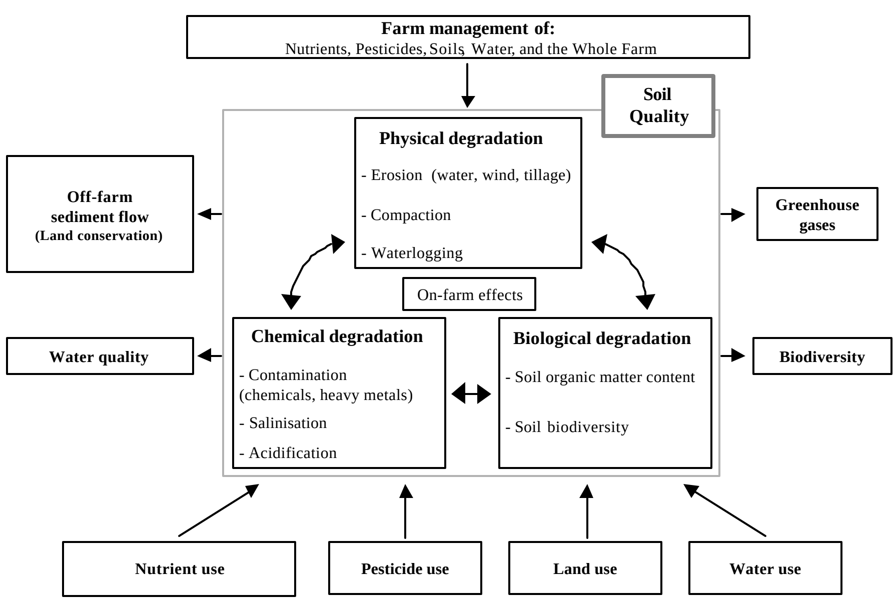
4.1. Domestic Environmental Issues: Agriculture's Impact on Soil Resources

The soil quality issue is significant to policy makers because some aspects of soil degradation are only slowly reversible (declining organic matter) or irreversible (erosion), although the relative importance of each issue varies between countries. Essentially agricultural policy makers need to balance three key aspects of soil quality: sustaining soil fertility, conserving environmental quality, and protecting plant, animal and human health. Hence, soil quality indicators are needed by policy makers to:

- monitor the long term effects of farm management practices on soil quality;
- assess the economic impact of alternative management practices designed to improve soil quality, such as cover crops and minimum tillage practices;
- examine the effectiveness of policies designed to address the agricultural soil quality issue;
- improve policy analysis of soil quality issues by including not only environmental values but also taking into account economic and social factors;
- evaluate the likely production, price and trade effects of using different policy measures to achieve specific objectives to improve soil quality, such as a 10% reduction in soil erosion.

Soil quality can be degraded through three processes: physical, chemical and biological degradation (Figure 12). It should be emphasised that many of the elements shown in Figure 12 are closely linked and will be affected by similar phenomena. For example, the overall extent of water and wind erosion partly depends on the intensity of rainfall and the magnitude of the slope of agricultural land, as well as the chemical and biological condition of the soil. Many of the processes shown in Figure 1 are covered by the current set of AEIs being developed by OECD, and within the NAFTA.

Figure 12**. Linkages between Soil Quality and other Agri-environmental issues**



Source: OECD (2001a)

Overall ***soil quality in Canada*** has improved during the period 1981-1996, particularly with respect to water, wind and tillage erosion, soil salinisation and compaction (Table 1). Nevertheless, almost 5 million hectares (or 7% of the total agricultural area) of marginal prairie land continues to be cultivated with a high risk of soil degradation. At the same time, the adoption of soil conservation practices has increased significantly since 1981, and as a result some agricultural soils are improving in quality and becoming less susceptible to erosion (McRae, et al 2000).

Table 1. **Share of agricultural land area affected by different soil quality issues [1]: Canada, 1981 to 1996**

	Water erosion		Wind erosion [1]		Tillage erosion		Soil salinisation [1]		Soil compaction [2]	
Area assessed million ha [3]	40		34		40		34		4	
Level of risk [4]	Average [5]	Range [6]	Average [5]	Range [6]	Average [5]	Range [6]	Average [5]	Range [6]	Area affected	Range [6]
	%		%		%		%		%	
Tolerable / Low										
1996	92	72-95	77	..	68	54-94	56	42-76	11	4-18
1981	88	66-93	63	..	58	43-92	56	50-75	13	4-22
Change	+4	n.a.	+14	..	+10	n.a.	0	n.a.	-2	n.a.
Moderate				..						
1996	5	3-12	17	..	31	6-46	33	20-42	..	..
1981	7	2-22	22	..	39	8-52	30	21-39	..	..
Change	-2	n.a.	-5	..	-7	n.a.	+3	n.a.	..	..
High / Severe										
1996	2	0-11	6	..	0	0-10	11	4-21	9	1-16
1981	5	0-12	15	..	4	0-11	14	4-22	6	1-9
Change	-3	n.a.	-9	..	-4	n.a.	-3	n.a.	+3	n.a.

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

Notes:

1. Data only relate to Prairie Provinces (i.e. Alberta, Saskatchewan, and Manitoba), i.e. 46% of Canadian agricultural land area, although the Provinces of Newfoundland and Labrador were not included in the calculations.
2. Data cover Ontario and the Maritime Provinces (New Brunswick, Nova Scotia and Prince Edward Island) i.e. 5% of Canadian agricultural land. Data under the High/Severe category cover soils susceptible to compaction under cropping systems that cause compaction. Data under the Tolerable/Low category, highly compacted soils under cropping systems that reduce soil compaction are reported.
3. The spatial coverage measured by each soil quality indicator varies, see total area assessed by each respective soil quality category.
4. The level of risk uses different units for each soil quality category, for example, for water erosion tonnes of soil lost/hectare, and for salinisation areas at risk to salinity.
5. Average percentages may not add to 100% due to rounding areas.
6. The range of risk for each respective soil quality category is measured at the level of Provinces, i.e. Canada has 10 Provinces, although of varying surface area, e.g. Sasketchewan, 19 million ha, and Nova Scotia, 0.13 million ha.

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

The decreasing risk of water erosion in Canada between 1981-1996 reflects the combined effects of reduced tillage, less intensive crop production, a decline in summerfallow, and the removal of marginal land from production. The declining risk of tillage erosion has been linked to the adoption by farmers of conservation tillage and no-till practices, made possible by the advent of direct seeding equipment and the use of chemicals to control weeds. Less intensive production, the reduced area under summerfallow and the removal of marginal land from production also contributed to the decrease in tillage erosion risk. The reduction in tillage across the prairies in Canada has also resulted in a 20-25% decline in the risk from wind erosion, although changes in the types of crop cultivated and the frequency of summerfallow have also contributed to this trend.

While damage to the ***quality of agricultural soils in the United States*** remains a major environmental problem there have been significant gains in reducing threats to the productive capacity of agricultural land, particularly over the past decade. The amount of land still requiring conservation treatment to maintain productivity fell by nearly a quarter between 1982 to 1992. This was in part because of land retirement, but also because of the adoption of soil conserving crop management practices such as conservation tillage (USDA, 1997).

It is estimated that agricultural activities are responsible for around 60% of total soil erosion in the United States. The remaining 40% results from natural events, mainly fire, flooding and drought, and also from activities such as forestry, construction, and off-road vehicle use. Erosive forces, water and wind, are calculated to have removed nearly 2.8 billion tonnes of soil from agricultural land in 1982, declining to 1.9 billion tonnes by 1992 (Figure 2).

Much of this improvement has been due to the increased use of soil conservation practices by farmers such as crop residue management, contour tillage and land retirement. In 1995 about 35% of cultivated cropland was under conservation tillage, an increase of 37% from 1989. Moreover, the Conservation Reserve Program (CRP) provided incentives to plant trees and develop windbreaks on environmentally sensitive land. The average annual soil erosion on CRP land between 1982 to 1992 declined from 46 to under 4 tonnes/hectare, with results from 1992 to 1998 indicating a continuation of this downward trend. However, about one-quarter of total agricultural land continues to be subject to erosion rates which could impair the long-term productivity of the soil (Figure 2). In addition, the off-farm damage from soil erosion has been estimated at US$2-8 billion annually (USDA, 1997).

4.2. The Domestic Consequences for NAFTA Countries of Agricultural Trade Liberalisation: The Case of Nitrogen Pollution from Livestock[2]

Agricultural trade liberalisation has the potential to contribute to overall improvements in environmental performance. Further reductions of barriers to agricultural trade will have both positive and negative impacts on the environment. A reduction of trade barriers will influence the overall scale of agricultural activities, the structure of agricultural production in different countries, the mix of inputs and outputs, the production technology, and the regulatory framework. These adjustments, in turn, will impact on the international and domestic environment by increasing or reducing environmental harm and creating or destroying environmental amenities.

International environmental effects include transboundary spill-overs, such as greenhouse gas emissions, changes in international transport flows, and the potential introduction of non-native species, pests and diseases. Domestic environmental effects include ground- and surfacewater pollution from fertiliser and pesticide run-offs, and changes in land-use that affect flood protection, soil quality, and biodiversity.

The direction and magnitude of some of these environmental impacts has been analysed in the OECD by combining preliminary results on the commodity market impacts of agricultural trade liberalisation with AEIs. With respect to domestic environmental impacts, the overall quantitative analysis suggests that agricultural prices and production intensity would decrease in countries that have had historically high levels of fertiliser and pesticide application, so that environmental stress in these countries would be relieved. Countries where increases in production intensity occur might be able to accommodate increased application rates of agro-chemicals relatively easily, as their historical levels of fertiliser and pesticide use tend to be low. Projections on the effects of further agricultural trade liberalisation on land use do not suggest substantial changes in agricultural land.

2. This section draws on the OECD (2000a) report.

More specifically, the OECD analysis also examined the impact of possible trade liberalisation scenarios on nitrogen pollution from livestock waste. In NAFTA countries this issue is of growing significance because of the major structural changes that have recently occurred in the livestock industry. The growing concentration of the livestock industry, especially in the pig and poultry sectors, and to a lesser extent the dairy sector, has led to higher livestock densities in some regions and concerns related to the environmental and health impacts of disposing of livestock waste.

In the OECD ***assessment of the impact of trade liberalisation on livestock nitrogen manure production*** a baseline and a trade liberalisation scenario, simulating an extension of the Uruguay Round Agreement on Agriculture (URAA) beyond the year 2000, are compared with the quantity of nitrogen (N) in animal waste in 1995-97. However, the trade liberalisation modelled in this case is not a complete removal of all trade barriers. Rather it only represents the continuation of the proportional annual rates of reduction in tariffs and export subsidies applied during the URAA implementation period (1995-2000) out to 2004. In the base-line scenario, the URAA commitments are held constant.

The results indicate in most OECD countries, further agricultural trade liberalisation would tend to reduce the amount of nitrogen from animal waste, with increased production in non-OECD countries (Table 2). One exception is Mexico, where an extension of the URAA commitments is expected to increase the amount of nitrogen from livestock compared with the baseline. In general, the impact is greater (a larger decrease) in those countries with higher support levels. The overall impact of an extension of the URAA on nitrogen generated by livestock is very small relative to the initial nitrogen surpluses in 1995-97 and to the other factors influencing production levels.

Table 2. **Impact of an extension of the Uruguay Round commitments on nitrogen quantity in livestock waste: 1995-97 to 2004**

	N from animal Waste in 1995-97	N from animal waste w/o URAA extension	N from animal waste with URAA extension	Impact of URAA extension	N from animal Waste w/o URAA extension	N from animal waste with URAA extension	Impact of URAA extension
	'000 t of N	'000 t of N			Per cent change in N		
Australia	2 501.7	2 477.6	2 476.6	-0.9	-1.0	-1.0	0.0
Canada	1 234.9	1 382.5	1 378.3	-4.2	12.0	11.6	-0.3
EU-15	7 921.9	7 912.7	7 883.9	-28.7	-0.1	-0.5	-0.4
Hungary	127.0	150.0	149.6	-0.4	18.1	17.8	-0.3
Japan	762.2	778.5	776.2	-2.2	2.1	1.8	-0.3
Korea	311.4	293.7	293.5	-0.2	-5.7	-5.8	-0.1
Mexico	1 775.0	2 127.5	2 129.2	1.7	19.9	20.0	0.1
New Zealand	1 390.7	1 497.5	1 496.6	-0.9	7.7	7.6	-0.1
Poland	540.0	608.3	608.7	0.3	12.7	12.7	0.1
USA	10 171.6	11 238.1	11 241.4	3.2	10.5	10.5	0.0
Total	26 736.6	28 466.5	28 434.0	-32.5	6.5	6.3	-0.1

Source: OECD 2000a

Trade liberalisation might also ***accelerate the trend to larger livestock units***. In previously protected markets, the trade-induced fall in output prices might have adverse impacts on farm incomes and force livestock farmers to increase the size of their animal holdings to make up for reduced per-unit profits through increased output. Alternatively, livestock farmers could partly or entirely switch to other agricultural or non-agricultural activities to maintain income. A similar increase in production scale is likely to occur in countries that experience an increase in livestock prices as a result of trade liberalisation. It is generally easier and less costly for livestock farmers to enlarge an existing operation than for newcomers to enter the sub-sector (Jones, 2001).

A further concentration of livestock production at the regional level might also occur. Liberalised trade will tend to both foster competition and facilitate technology transfer. Those livestock producers with well co-ordinated relationships to upstream and downstream enterprises and access to high-quality extension services will tend to be best placed to exploit new opportunities in a more globalised market. Regional clusters with several feed suppliers and livestock processors and specialised advisory services in the vicinity could prosper, especially for pig and poultry operations, and to an increasing extent dairy farms as well. However, the overall effect of further trade liberalisation on regional clustering of livestock operations is difficult to quantify, in particular, because of the influence of other factors driving structural change, such as technological developments and varying environmental standards and regulations across different regions within the same country.

4.3. Using Agri-Environmental Indicators in Projection Studies: Climate Change[3]

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

Agricultural GHG emissions contributed about 8% of total OECD emissions in 1995-97 (in CO_2 equivalents), but this masks considerable variation across countries (Figure 9). While the contribution of agriculture to the main GHG gas, carbon dioxide (CO_2) is only about 1%, it accounts for 60% of total OECD nitrous oxide (N_2O), and nearly 40% of methane (CH_4) emissions. Livestock enteric fermentation, manure and the use of inorganic fertilisers account for the major share of agricultural GHGs in most OECD countries, but the shares of other emission sources are also important for some countries, notably crop residues, biomass burning, and wetland rice cultivation.

Projections of agricultural GHG emissions to 2020 reveal a varied picture across OECD countries (Figure 13). The percentage change in agricultural emissions from 1990 to 2020 will be lower than the Kyoto emissions targets set for 2008-12 in Australia, Czech Republic, the European Union, Poland and Switzerland, only slightly above the targets for Japan, Norway and the United States, and significantly higher than the Kyoto commitments for Canada, Hungary and New Zealand (Table 3). These estimates are based on projections of livestock and rice production, however, they understate the likely level of agricultural GHG emissions, because a number of emission sources are excluded (due to a lack of data), notably fertiliser use, fossil fuel combustion, biomass burning, and changing farm management practices and land use patterns. They also ignore the possibility of further progress to agree to reduce emissions amongst the signatories to the UNFCCC.

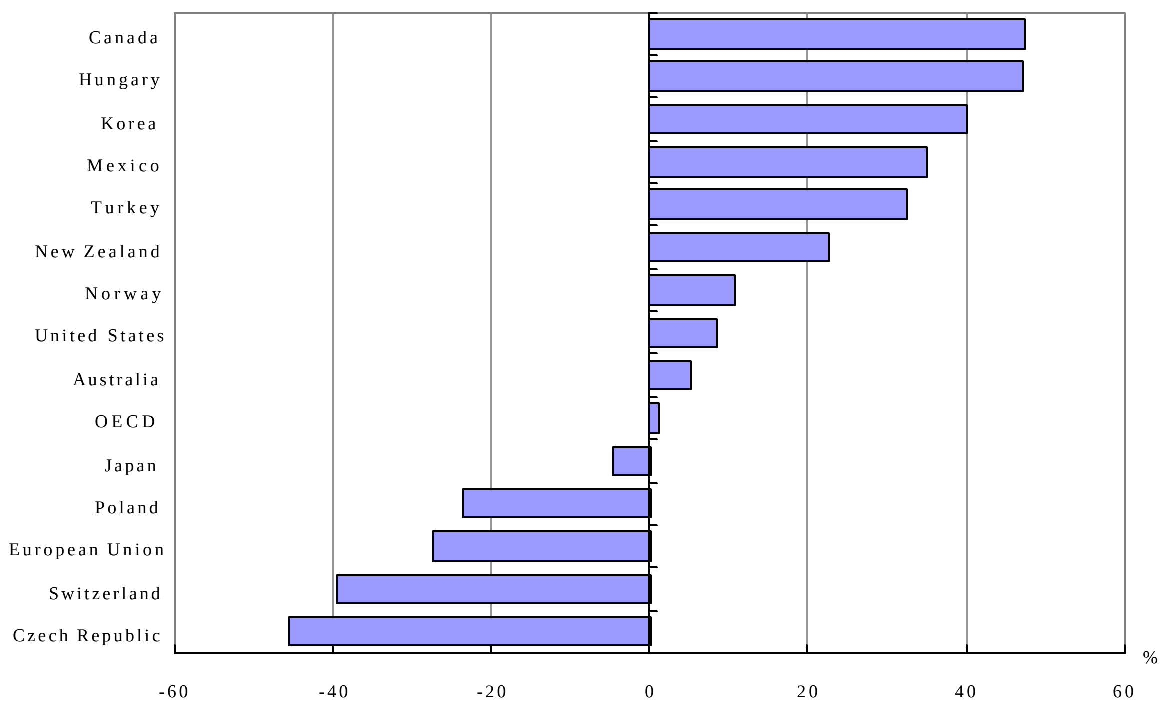
But these projections of GHG emissions, also do not take account of the ***role of agriculture as a sink for GHGs***. Currently there are no systematic estimates across OECD countries of the capacity of agriculture in sequestering (removing) carbon (C) in soils. The C sequestration capacity of agriculture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

3. This section draws on the OECD (2001b) report.

Future changes in sequestering C by altering farming practices and production intensity, is thought to increase soil C slowly over the first 2 to 5 years, with larger increases between 5-10 years, reaching a finite limit after about 50 years. It is estimated for the United States that such changes in farm land use and management practices could reduce total US GHG emissions by 8%. Recent trends for some OECD countries indicate a growing number of farmers using conservation tillage practices and increasing the number of days per year the soil has a vegetative cover. In addition, if the EU, Japan and the US, and some other OECD countries, continue to keep agricultural land out of production this could have a positive impact for soil C sequestration depending on how this land is managed in future.

Agriculture also has the potential to reduce GHG emissions through the replacement of fossil fuels with ***biomass energy***, from crops. International Energy Agency (IEA) projections expect non-hydro renewable energy (NHRE) sources (mainly geothermal, solar, wind, tide and biomass) to be the world's fastest growing primary energy source up to 2020 at nearly 3% per annum. Most of this is accounted for by OECD countries, and the contribution of biomass in world total NHRE may decline from nearly 75% to about 50%. Despite the rapid growth in NHRE production the share of these energy sources in total OECD electricity production is small but projected to rise from 2% to 4% between 1997 to 2020. While concerns over climate change may encourage the production of renewable energy sources they are likely to remain expensive compared to fossil fuels and will therefore require financial incentives to achieve the projected growth rates by 2020 (IEA, 2000; and OECD, 2001c).

Figure 13**. Projections of Greenhouse Gas Emissions from Livestock and Rice Production, 1990 to 2020**



Source: OECD (2001b).

Table 3**. Agricultural Greenhouse Gas emissions in 1990-92 and projections to 2020**

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

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

Notes:

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

Source: OECD (2001b).

5. What are the Future Challenges to Improve the Environmental Assessment of Agriculture for Policy Purposes?

The future challenges in improving the environmental assessment of agriculture are to meet the objectives of: providing information on the current state and changes in the environmental performance of agriculture; and using indicators for policy monitoring, evaluation and forecasting purposes. For some environmental issues there is incomplete knowledge and data to establish trends, for example, concerning the degree of groundwater pollution or rate of depletion resulting from farming. 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. Also for a number of areas, notably agriculture's impact on biodiversity, the understanding and measurement of these impacts is still at a preliminary stage of research.

To meet the increasing demand for an improved agri-environmental information base for policy makers and the wider public will require further work in six key areas:

1. ***Enhancing the analytical soundness and measurability of indicators,*** such as a better understanding and measurement of agriculture soil carbon sinks, and also how to best track agriculture's impact on biodiversity, including importantly in NAFTA countries the impact of non-native species. For the carbon sink issue, OECD is organising an Expert Meeting in October 2002 to examine national reporting systems and indicators to track carbon levels in agricultural soils, to be hosted by Agriculture Canada; while for agri-biodiversity indicators the Swiss authorities hosted an OECD Expert Meeting in November 2001 (see the Meeting documentation on the OECD agri-environmental indicator website at: http://www.oecd.org/agr/env/indicators.htm

2. ***Overcoming data deficiencies, enhancing monitoring activities and increasing efforts of the supporting science.*** The current lack of data and extensive monitoring systems is an impediment to further enhancing AEI data sets. However, there exists considerable potential to further exploit existing databases from which to generate AEIs, and use new information technologies to further develop databases at 'relatively' low cost. Nevertheless, improving basic scientific understanding of some agri-environmental linkages, such as those related to pesticides, biodiversity and climate change, will be critical to help better guide monitoring and data collection efforts.

3. ***Improving interpretation of indicator trends***, especially through better expression of the spatial variation of national level indicators, and developing appropriate baselines, threshold levels and targets to help assess policy performance. Some OECD countries are beginning to establish environmental targets by which to monitor and evaluate policy performance. The OECD Environment Ministers (May, 2001) noted in the *OECD Environmental Strategy for the First Decade of the 21st Century,* that there is a need to "...further develop and use indicators and targets to measure environmental progress at the national level".

4. ***Measuring the external environmental costs and benefits of agriculture***, by translating AEIs measured in physical terms (e.g. mg/l of nitrates in surface water) into monetary terms (e.g. capital and operating costs to water companies on nitrate removal) (see Pretty, *et al* 2000, for example). This would help provide the basis to assess the magnitude of different environmental issues on a comparable basis (e.g. costs of soil erosion relative to water pollution, and the benefits of plant genetic resource conservation), and for agriculture better relate policy measures to environmental outcomes (e.g. the effects of lowering agricultural water supply charges on the costs of groundwater depletion).

5. ***Using agri-environmental indicators to better inform policy monitoring, evaluation and projections***, for example, monitoring agriculture's compliance with water quality standards; evaluating the effects of irrigation water and infrastructure subsidies on irrigation management and water use; and projecting future production, price and trade effects of achieving specific environmental objectives in agriculture, such as reducing rates of soil erosion or groundwater depletion. The use of AEIs for policy purposes is a developing field in most cases, and consequently policy analysts are confronted with incomplete and fragmented information. Equally the use of analytical models to link environmental performance to policy impacts is frequently impeded by a lack of indicators and associated data sets to support such analysis.

6. ***Developing indicators that can help to examine synergies and trade-offs between the economic, social and environmental dimensions of sustainable agriculture***. The sustainable agriculture concept emphasises the links between the economic, social and environmental dimensions. The OECD AEIs recognise these dimensions of sustainable agriculture, for example, through farm financial resources (economic); farmer educational levels (social) and water quality (environmental) indicators. But it is also necessary to show the linkages between the three dimensions of sustainable agriculture, for example, measures of resource productivity (economic-environment) and the health consequences of agricultural activities (environment and social).

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

Annex 1. **Complete list of OECD Agri-environmental Indicators**

I. AGRICULTURE IN THE BROADER ECONOMIC, SOCIAL AND ENVIRONMENTAL CONTEXT		
1 Contextual Information and Indicators		**2 Farm Financial Resources**
• *Agricultural GDP*	• *Land use* – Stock of agricultural land – Change in agricultural land – Agricultural land use	• *Farm income*
• *Agricultural output*		• *Agri-environmental expenditure* – Public and private agri-environmental expenditure – Expenditure on agri-environmental research
• *Farm employment*		
• *Farmer age/gender distribution*		
• *Farmer education*		
• *Number of farms*		
• *Agricultural support*		
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	• *Soil and land management* – Soil cover – Land management practices
	• *Pest management* – Use of non-chemical pest control methods – Use of integrated pest management	• *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*	• *Pesticide use*	• *Water use intensity*
• *Nitrogen efficiency*	• *Pesticide risk*	• *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*	• *Water retaining capacity*	• *Gross agricultural greenhouse gas emissions*
	• *Off-farm sediment flow (soil retaining capacity)*	
2 Water Quality		
• *Water quality risk indicator* • *Water quality state indicator*		
5 Biodiversity	**6 Wildlife Habitats**	**7 Landscape**
• *Genetic diversity*	• *Intensively-farmed agricultural habitats*	• *Structure of landscapes* – Environmental features and land use patterns – Man-made objects (cultural features)
• *Species diversity* – Wild species – Non-native species	• *Semi-natural agricultural habitats*	
	• *Uncultivated natural habitats*	
	• *Habitat matrix*	
• *Eco-system diversity* (see Wildlife Habitats)		• *Landscape management*
		• *Landscape costs and benefits*

Source: OECD 2001a.

Annex 2. **The Use of Agri-environmental Indicators in Recent OECD Studies and Activities**

Agri–environmental indicators (AEIs) have been used as supporting information across a range of recent OECD studies and activities, as outlined below.

- *Agricultural Policies in OECD Countries Monitoring and Evaluation Report*, an annual report which includes information and data on the effects of agriculture on the environment (OECD, 2001d). For further information see the OECD agriculture website at: http://www.oecd.org/agr/

- *Agri–environmental related policy studies*, an irregular series of reports which examine different agri-environmental related policy issues, summarised in OECD (2001e). For further information on related agri-environmental studies see the web–site: http://www.oecd.org/agr/policy/ag-env/index.htm

- *Review of Agricultural Policies,* are country policy reviews of non-member OECD countries, such as the recent reviews of Romania (OECD, 2000c) and Slovenia (OECD, 2000d), which have used the AEIs in the sections covering agri-environmental issues. For further information go to: http://www.oecd.org/oecd/pages/home/displaygeneral/0,3380,EN-about-152-4-no-no-no-152,FF.html

- *Environmental Performance Review* country series examine the environmental performance of OECD countries and some non-OECD countries, including in certain reviews a special feature on agriculture drawing on the AEIs, for example, Denmark (OECD, 1999b). For further information go to: http://www1.oecd.org/env/performance/index.htm

- *Economic Working Papers,* with special focus in some papers on sustainable development, including reference to agriculture, see for example Finland (OECD, 2000e) and Norway (OECD, 1999c). For the OECD Economic Working Paper series go to: http://www.oecd.org/oecd/pages/home/displaygeneral/0,3380,EN-documents-notheme-8-no-10-no-0,FF.html

- *Agricultural and Environmental Outlook Reports,* these include a recent paper on the long term environmental outlook for agriculture in OECD countries to 2020 in (OECD, 2001b), and a chapter on agriculture in the OECD (2001c) *Environmental Outlook* publication. For further information on this activity see: http://www.oecd.org//env/outlook/outlook.htm

- *Sustainable development,* is a major horizontal activity for the OECD, examining the broader economic, social and environmental dimensions of sustainable development, including reference to issues related to sustainable agriculture, natural resources and indicators (see OECD, 2001f; and the OECD sustainable development web-site: http://www.oecd.org/subject/sustdev).

Source: OECD Secretariat, 2002

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