OECD AGRI-ENVIRONMENTAL INDICATORS: WORK IN PROGRESS

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Abstract: A number of challenges confront statisticians, economists and policy analysts concerned with environmental monitoring and policy analysis, in particular to: improve the availability and the quality of data; enhance the dialogue between economists, statisticians and policy analyst; and produce policy relevant and analytical sound agri-environmental indicators (AEIs). In its policy and indicators work on agriculture and the environment, the OECD has been addressing these challenges, and the paper describes how the OECD has started to develop a set of AEIs. The paper proceeds to describe the policy context of sustainable agriculture and then sets out to answer a range of questions: why measure sustainable agriculture; how should indicators be selected to measure sustainable agriculture; what progress has been made by OECD in developing indicators; how can indicators serve policy decision makers and other stakeholders; and finally, what are the future challenges in developing indicators that can monitor national progress towards sustainable agriculture?[1]

Introduction

"It would be very helpful, for purposes of environmental management, to have reliable measures of change at both the national and global levels. Evidently a time series of simple measures, such as ratios, based on readily available statistics ......could serve such a purpose......On the other hand, it is hard to see why a set of simple measures...has never been prepared and published by any national or international statistical agency. The relatively low cost of such an effort, by international standards, makes the omission all the more incomprehensible" (Ayres, 1996).

"Transactions between statistical agencies and the research or analytical agencies and "policy shop[s]".....where the statistical products are used have long exhibited a weakness that is critical in an era requiring greater integration and coordination of decision systems.....Serious mismatches between the characteristics of the statistical products used and the data requirements of analysis result in low quality or badly flawed data for analysis and, thus, often flawed information for decisions....We need to think more carefully about what is necessary to make [the] transaction between statisticians and analysts an effective one for users of information" (Bonnen, 1997).

"When .... environmental indicators are collected for pragmatic purposes, the set of indicators chosen, and the performance measures attached to them, depend on who is asking the policy question, the purpose of the agency and the clients it serves. In this regard, it becomes clear again that indicators carry political, as well as intellectual value. They may be used, misused or ignored entirely in the pursuit of specific political aims. Yet the role of indicators is critical in making well informed social choices. Without them, we risk shortsighted and seriously flawed decision making. The current state of research on environmental indicators is reminiscent of the early stages of national income accounts. Experimentation and inconsistencies are inevitable at the beginning. Nonetheless, research must press forward in order to produce rigorous and meaningful indicators." (Ervin, Batie and Livingston 1995).

The above quotations illustrate the key challenges that confront statisticians, economists and policy makers concerned with environmental monitoring and policy analysis, to:

- improve the availability and the quality of data ;
- enhance the dialogue between economists, statisticians and policy analysts;
- produce policy relevant and analytical sound agri-environmental indicators.

The Challenge Of Achieving Sustainable Agriculture

[1] This paper draws from material provided in the OECD (1999) publication: *Measuring the Environmental Impacts of Agriculture: The York Workshop,* and an extract from the OECD (1999, pp58-61) report: *Agricultural Policies in OECD Countries -- Monitoring and Evaluation*.

The basic long-term challenge to achieve sustainable agriculture is to produce sufficient food and industrial crops efficiently, profitably and safely, to meet a growing world demand without degrading natural resources and the environment (OECD 1995). While agricultural productivity has been substantially improved, it has often been accompanied by resource degradation, such as soil erosion and water depletion. But farmers have also made positive contributions to landscapes and the maintenance of rural communities and agricultural land can also provide important habitats for wildlife and act as a sink for greenhouse gases (Legg, 1999).

Because of differences in climate, agro-ecosystems, population density and levels of economic development, the relative importance of particular environmental issues varies widely between and within countries. These differences are also reflected in varying perceptions as to what is meant by the "environment" in agriculture. For some, the "environment" covers only biophysical and ecological aspects, while for others, landscape, cultural features, and rural development are also important. In recent years, the quality and safety of food, and the welfare of farm animals, have become more prominent policy issues, perceived as being closely related with the environment.

The environmental implications of farmers' actions, however, are not always incorporated in their costs and revenues, such as when agricultural chemicals leach into groundwater, thereby raising the costs of treating water for drinking. Or, for example, when farmers refrain from taking actions that would add to environmental services, such as conserving land as habitat for wildlife, because ways of making the beneficiaries compensate farmers for the associated costs are lacking.

In many cases environmental problems have been aggravated by agricultural and trade policies that distort price signals by linking support to agricultural commodities, or by disguising the costs of inputs. The economic distortions created by such policies can lead to environmentally inappropriate patterns and location of production and harmful use of inputs, and discourage the development and use of farming technologies less stressful on the environment (OECD, 1998a).

The reform of agricultural policies should improve the domestic and international allocation of resources, reduce incentives to use polluting chemical inputs and farm environmentally sensitive land. Hence, by reducing output and input use (due to a combination of lower output prices and changes in relative factor prices), the reforms would tend to reverse the harmful environmental impacts associated with commodity and input specific policy measures. But in those cases where agricultural policies are associated with maintaining farming activities that provide environmental benefits, policy reform can reduce environmental performance (OECD, 1998b).

As agricultural policy reforms have been introduced only recently in most OECD countries, some caution needs to be exercised when assessing the overall environmental effects. Recent OECD work has recognised that agricultural policy reform is a necessary, but not always a sufficient condition to improve the environmental performance of agriculture.

Given the diversity and site specificity of agro-ecological conditions, local, farmer-based approaches, coupled with relevant research, development, training, information and advice would appear to be high on the list of "sound" policy practices. These approaches focus on the "public good" aspects of agriculture, reflect the differences across farming, allow for the development of market-based innovations, and recognise that policy responses are required where markets fail to take account of the non-marketed impacts of agriculture on the environment.

Why Measure Sustainable Agriculture?

If decisions are to be made to encourage a sustainable agriculture then it will be necessary to provide analysis, measurement and responses to assist in this decision-making process. The analysis of sustainable agriculture, especially the environmental dimension, involves answering a number of key questions (Pearce, 1999):

- What are the external benefits and costs of agriculture and how much is society prepared to pay to meet environmental objectives, taking into account the trade-offs between these objectives and that agriculture also meets economic and social goals, such as through producing food and creating jobs?

- What is the relationship between government policy and agriculture and the consequences for achieving sustainable agriculture, especially the production and trade distortions created by production linked subsidies, recognising that markets can help reduce negative environmental impacts but may fail to take account of the non-market effects of farming on the environment?

- What are the underlying causes and effects of agriculture's impact on the environment, not only, for example, nitrogen runoff and water pollution, but why nitrogen runoff occurs in the first place?

It is evident from a wide range of activities, now underway both locally, nationally and internationally, that a considerable effort is taking place to provide analysis and develop a set of indicators to help answer and respond to the type of questions outlined above. Illustrative of these activities include the follow-up to the ***United Nations Conference on Environment and Development*** (UNCED) Rio Declaration and Agenda 21, with the development of a set of sustainable development indicators, including agriculture (UNCSD, 1996). Under the auspices of the ***World Trade Organisation***, there is an ongoing discussion on trade and environment, with a recent submission by Norway, for example, on the environmental effects of trade liberalisation in the agricultural sector, drawing on agri-environmental indicators in their analysis (WTO, 1999).

At the meeting of ***OECD Agricultural Ministers*** in 1998, they identified a role for OECD to, amongst other tasks, foster sustainable development through analysing and measuring the effects on the environment of domestic agricultural and agri-environmental policies and trade measures (OECD 1998c). Also at the ***European Union 1998 Cardiff and Vienna Summits*** the importance of developing environmental indicators was underlined, including for the agricultural sector, to ensure that environmental issues are adequately evaluated to help in the decisions to be made on agricultural policies within the context of Agenda 2000 (Commission of the EC, 1999).

In the ***United Kingdom***, for example, as part of its national sustainable development strategy the government is devising a set of sustainable development indicators (DOE, 1996; DETR, 1998). To complement this work the Ministry of Agriculture, Fisheries and Food (MAFF, 1998), recently published a consultation document with proposals for a set of UK indicators for sustainable agriculture. This effort is being supported by various indicator work at the sub-national level. An example in the UK, is the use of indicators to measure change in the North York Moors National Park (NYMNP), which includes coverage of agri-environmental issues (NYMNP 1998).

How Should Indicators Be Selected To Monitor Sustainable Agriculture?

In order to help select and develop appropriate indicators to monitor sustainable agriculture, work undertaken by OECD on agri-environmental indicators (AEIs), has suggested that they should possess a number of attributes (OECD, 1997a). This implies that indicators must be:

- ***policy-relevant***, that is they should be demand (issue) rather than supply (data) driven, and address the 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;

- ***easy to interpret*** and communicate essential information to policy makers; and,

- ***measurable***, that is feasible in terms of current or planned data availability and cost effective in terms of data collection, processing and dissemination.

To help improve information on the current impacts and trends in the environmental effects of agriculture, the OECD is developing a set of agri-environmental indicators (AEIs) within the ***Driving Force–State–Response (DSR) framework***. This framework addresses a set of questions related to the linkages between causes, effects and actions:

- What is causing environmental conditions in agriculture to change, for example, changes in farm chemical input use (***Driving forces***)?

- What are the effects of agriculture on the environment, for example, the impacts on soil, water, air, and natural habitats (***State***)?

- What actions are being taken to respond to the changes in the state of the environment, for example, by farmers, consumers, the food industry and governments, such as promoting sustainable agriculture by community based approaches (***Responses***)?

The DSR framework has helped facilitate the process in OECD of arriving at a consensus on a set of preferred AEIs. The framework recognises explicitly that agri-environmental interactions and linkages are complex and multi-faceted, and provides a structure within which individual indicators can be placed in context (Moxey, 1999). As with any classification system, the boundaries between drivers, states and responses may be unclear in some cases. However, the value of the DSR lies not so much in the precise categorisation of individual indicators, but rather in the provision of a common framework within which indicators can be presented and debated.

At present, information on the agri-environmental linkages is fed through to policy makers in a relatively ad hoc manner. That is, information arrives from a variety of sources such as statistical survey data, mathematical models and expert opinions. AEIs are viewed as offering a more formal and routine manner of gathering and communicating information and once agreed upon, a set of AEIs can be used consistently. Developing AEIs to fulfil this purpose may be viewed as a three-stage process:

1. The identification and measurement of underlying agri-environmental linkages and conditions, involving dialogue between environmental scientists, social scientists and policy makers to agree upon areas of concern, current understanding of causality and availability of data to describe conditions and linkages;

2. The incorporation of physical AEIs into an economic framework to allow explicit consideration of trade-offs between agri-environmental conditions and productive capacity, be that within agriculture or indeed elsewhere in the economy, involving consideration of methodologies for ranking and valuing agri-environmental goods and services.

3. The extension of stage 2 to the policy making arena as a decision support tool for exploring the trade-offs involved in alternative policy scenarios, involving consideration of how AEIs should be interpreted.

What Progress Has Been Made In Developing Indicators?

Within the context of the DSR framework and building on previous OECD work on indicators (OECD, 1997a; 1999a), this has led to considerable progress in both the identification and specification of policy-relevant indicators as listed in Figure 1.[2] In summary, the indicators are being developed to cover primary agriculture's:

- use of natural resources and farm inputs: nutrients, pesticides, water and land;

- environmental impact on: soil and water quality, land conservation; greenhouse gas emissions, biodiversity, wildlife habitats and landscape; and,

- interaction between environmental, economic and social factors, such as farm management practices; farm financial resources; and rural viability.

Progress in establishing indicators across those listed in Figure 2 is variable, in particular, because research on issues such as agricultural biodiversity is relatively recent compared to, for example, farm nutrient use. Some preliminary results of the OECD agri-environmental indicator work, however, reveal that the environmental performance in agriculture has generally tended to improve over the past 10 to 15 years for many OECD countries, although the magnitude of improvement varies among countries (Figure 2).

The potential *nitrogen loading* on the environment from agriculture, for example, as measured by the nitrogen soil surface balance indicator, has declined for most OECD countries (OECD, 1999b and Figure 2).[3] For certain countries, such as Hungary, this reduction in nitrogen surplus is particularly large, affected by the collapse in agricultural support levels, the elimination of input subsidies and increasing debt levels in the farm sector, following the transition toward a market economy (OECD, 1998a).

The quantities of *pesticides* used by agriculture, have also decreased for many OECD countries (Figure 2). However, a change in pesticide use may not reflect a change in environmental damage from their use because of the variable environmental risk associated with different pesticides. Even so, research in Denmark and Sweden for example, has revealed a close correlation between declining pesticide use and environmental risk.

There has generally been a small reduction in emissions of *greenhouse gases* from agriculture during the past six years (Figure 2). The contribution of agriculture in helping toward meeting national commitments under the Kyoto Climate Change Protocol might be important in the new millennium, especially where the contribution of agricultural greenhouse gas emissions in total emissions is significant, notably for Australia, Denmark, Ireland, and New Zealand.

In the area of agricultural *water use*, there has been a substantial expansion of agricultural land under irrigation in a number of OECD countries over the last two decades (Figure 2). This underlines the potential future risks in view of competing and growing demands for water from farmers, industry, households and other water users (OECD, 1998d).

How Can Indicators Serve Policy Decision-Makers And Other Stakeholders?

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[2] For a description of the specification of these indicators, see the OECD publication in footnote 1.

[3] The *agricultural nitrogen soil surface balance indicator* involves calculating the difference between all nitrogen inputs (mainly chemical fertilisers, livestock manure, nitrogen in rainfall and legume crops) and nitrogen uptake by agricultural crops (largely annual arable crops, such as cereals, and pasture used for livestock grazing). All OECD countries produce a national nitrogen surplus through this calculation (i.e. inputs of nitrogen are greater than uptake), but a nitrogen surplus only reveals the "potential" nitrogen loading on the environment (i.e. in the air, soil, water), as the "actual" loading or pollution will depend on a number of factors, such as local soil and climatic conditions, how and when livestock manure is spread on the soil. For a review of OECD work on nutrient balances, see Parris, 1998.

Many governments are beginning to invest in indicators as tools to aid policy making in a systematic way, to help answer a broad range of questions, including:

- What is the environmental impact of reducing subsidies to the agriculture sector?

- What are the environmental impacts of alternative agricultural policy instruments, such as direct payments versus market price support?

- What are the environmental impacts of extending current policies into the future?

- What are the economic implications for the agriculture sector of meeting environmental targets, such as those set out in international agreements?

The use of indicators as an aid to policy decision-making in the agri-environmental context is a relatively recent phenomenon and still a developing field, however, indicators are perceived to have considerable potential as policy tools. Most policy makers concerned with agri-environmental issues at the national level, are confronted with fragmented information and it is accordingly difficult to harness the information in a way that effectively contributes to policy decision making.

While indicators are being introduced into the policy-making process, they are being included in an ad hoc way in response to short-term policy pressures. Many of these pressures arise from new legislation and initiatives, which have introduced requirements to undertake evaluations and meet specific targets in respect of domestic agri-environmental schemes and international environmental agreements (Baldock, 1999).

One way in which AEIs can contribute to better inform decision makers, is through their integration into public policy analysis and models. Certainly, AEIs have been used in a variety of analytical and modelling exercises to increase the quantity and quality of information available for evaluating policy impacts (Thomassin, 1999). These include, the evaluation of specific policy instruments such as the environmental effects of land diversion schemes (OECD, 1997b); analysis of the environmental effects of changes in different agricultural policy instruments (Meudt, 1999); and the use of indicators in predicative analysis, for example, the future implications for agricultural markets and trade of reducing agricultural greenhouse gas emissions (OECD, 1999c).

The key to constructing successful models and informative analysis of agri-environmental policies, is developing an iterative dialogue between scientists, economists, modellers and policy makers. However, dialogue is only one element in developing successful agri-environmental policy analysis and models, there are also certain conceptual and methodological issues that need to be resolved including the:

- inclusion of economic and biophysical data, so that the links between economic and environmental activities can be mapped;

- enhanced understanding of the behavioural response of decision makers, such as farmers, to environmental signals provided by AEIs;

- endogenous treatment of both the economic and environmental aspects of policy; and,

- integration and interfacing of models developed at different spatial levels (e.g. the farm, region and country levels).

What Are The Future Challenges?

The development of environmental indicators is relatively recent compared to work on economic and social indicators. But whereas the latter are often concerned with the monetary measurement of human phenomena, environmental indicators aim to capture the relationship between the biophysical "natural" environment and human activities, usually measured in physical terms. This, in part, explains why environmental and sustainable agriculture indicators present a considerable challenge in the future.

Some of the ***key future challenges in indicator development*** relate to spatial scales; temporal dimensions; analysis of linkages between the different dimensions of sustainable agriculture; and, the valuation of the environmental costs and benefits of agricultural activity.

The ***spatial scales*** to measure AEIs varies from the field, farm, watershed, through to the ecozone and national levels. The capability to develop and measure indicators for a range of spatial scales is constrained by: the ability to extrapolate data from the field/farm level to higher levels; the trade-offs that occur with gains in coverage at higher levels but loss of the detail/variation at lower scales; and that information at different scales may require different indicators depending on the use, and users, of the information (McRae, 1995). From the OECD perspective data need to be captured at as detailed a level as possible then aggregated to the national level with some expression of the variation around the national average indicator value.

The variations in the ***temporal dimensions*** of different environmental effects of agriculture range from the short term, such as the impact on wildlife from pesticide use; medium term, for example depletion of groundwater reserves; and to the long term, which may involve decades in the case of soil erosion. The impacts on the environment from agricultural policies, economic and societal pressures may also have different time lags and consequences. While this problem is not uncommon to socio-economic indicators, there is nonetheless an important difference, as a key focus of sustainable development is intergenerational concerns. Most indicators, however, use a time series approach showing current trends, which presents a key challenge for indicator construction in terms of the current-future trade-off.

The sustainable development concept emphasises ***the links between the economic, social and environmental dimensions*** (Rennings and Wiggering, 1997). The OECD indicators recognise these dimensions of sustainable agriculture, for example, through farm financial (economic); rural viability (social) and water quality (environmental) indicators (Figure 1).[4] But it is also necessary to show the linkages between the three dimensions of sustainable agriculture, for example, between measures of resource productivity and the health consequences of agri-environmental impacts.

Balancing economic imperatives (e.g. food production), with environmental impacts (e.g. conserving landscapes) and social concerns (e.g. preserving rural communities), requires some means of weighing up these impacts and concerns, such as using cost-benefit framework. Use of a cost-benefit framework highlights the need to develop AEIs that use a ***common monetary unit*** rather than physical measures, so that trade-offs and priorities can be more easily gauged by policy makers and the public.

As the challenges to indicator development are overcome and more indicators become operational they will enrich the information base for policy decision makers with an interest in agri-environmental issues. It is clear, however, that there is a gap between the current development of AEIs (indicator supply) and expectations for indicator delivery by policy makers and other stakeholders (indicator demand). These indicators are essential to make well-informed policy choices and without them there is a risk of making short-sighted and flawed decisions (Ervin, 1995).

It should be recognised that the process of developing agri-environmental indicators will be one of evolution and refinement, and that some indicators will evolve more rapidly than others. As different

[4] OECD will publish preliminary indicator results in its forthcoming (year 2000) report: *OECD Agri-environmental Indicators: Issues, Methods and Results*, Paris, France.

indicators are developed the linkages between them will be analysed to help better interpret trends in specific indicators. For example, changes in indicators of nutrient use (*driving force*), can be linked to variations in water quality (*state*) and related to the alteration in farm management practices (*responses*).

As national and international efforts advance to establish agri-environmental indicators they will need to command broad consensus in terms of their feasibility and policy relevance. Also it will be important that the indicators are valuable in interpreting trends in environmental conditions in agriculture and agricultural sustainability, are based on a consistent methodology to enhance their utility for international comparison, and are transparent so that all "stakeholders" can understand the indicators and the policy implications based on them.

FIGURE 1

LIST OF OECD AGRI-ENVIRONMENTAL INDICATORS

Contextual Indicators: Covering land, population and farm structures, including changes in -- agricultural land use and land cover; numbers of full time farmers; and numbers and type of farms.

Nutrient Use: Soil surface balances of nitrogen and phosphorous; farm gate nutrient balances; nutrient use efficiency (technical/ economic).

Pesticide Use: Index of pesticide use; pesticide use efficiency (technical/ economic); pesticide risk

Water Use: Water use intensity (proportion of water resources diverted to agricultural use); water stress (proportion of rivers subject to diversion); water use efficiency (technical/ economic); policy and management response to water stress.

Soil Quality: Risk of soil erosion by water and wind; inherent soil quality (agricultural areas where there is a mismatch between the soil capability and actual or impending use).

Water Quality: Nitrate and phosphorous concentration in water vulnerable areas; risk of water contamination by nitrogen and pesticides.

Land Conservation: Water buffering capacity (quantity of water stored in soil, on the land and by irrigation facilities and the relationship to downstream flooding); off-farm sediment flow (and the relationship to sedimentation of rivers, lakes and reservoirs).

Greenhouse Gas Emissions (GHG): gross agricultural emissions (methane, nitrous oxide and carbon dioxide); agriculture's contribution to renewable energy (biomass production); net emissions of carbon dioxide from agricultural soils; economic efficiency of agricultural GHG emissions.

Biodiversity: Genetic diversity of domesticated livestock and crops; wildlife species diversity (related to the quality and quantity of species diversity).

Wildlife Habitat: Intensively farmed, semi-natural agricultural habitats and uncultivated natural habitats; habitat heterogeneity and variability; impact on habitat of different farm practices/systems.

Landscape: Land characteristics (including natural features, ecosystem appearance; and land type features), cultural features (such as stonewalls); management functions of agricultural landscape; landscape typologies; monetary valuation of societal landscape preferences.

Farm Management: Farm management capacity (standards for environmental farm management practices; expenditure on agri-environmental research, educational level of farmers); on-farm management practices (adoption of environmental practices related to nutrients, soil, pesticides, water and whole farm management).

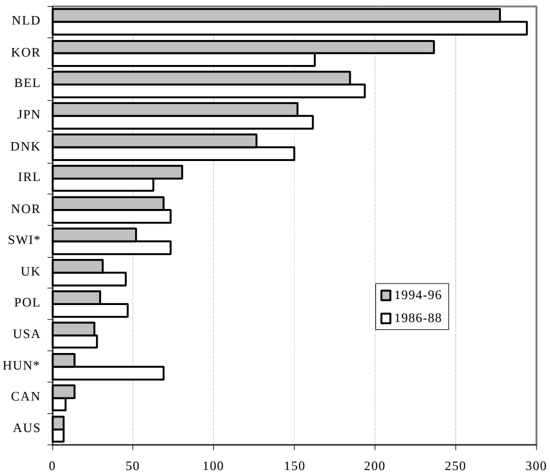
Farm Financial Resources: Public and private agri-environmental expenditure; farm financial equilibrium between net farm operating profit after tax and the cost of capital.

Rural Viability: Agricultural incomes; entry of new farmers into agriculture; social capital in agricultural and rural communities (strength of social institutions, voluntary organisations, etc.)

FIGURE 2

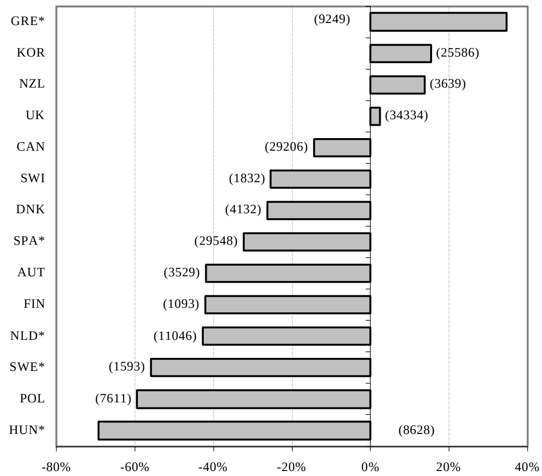
PRELIMINARY OECD AGRI-ENVIRONMENTAL INDICATORS

Agricultural nitrogen balance
(1986-88 and 1994-96, kg nitrogen/ha)



Notes:
Nitrogen (N) balance in kg per hectare of total agricultural land = N inputs (fertiliser manure, etc.) minus N plant uptake, which if > 0 = N surplus; if < 0 = N deficit.
*1986-88 to 1993-95
Source: OECD Agri-environmental Indicator Database.

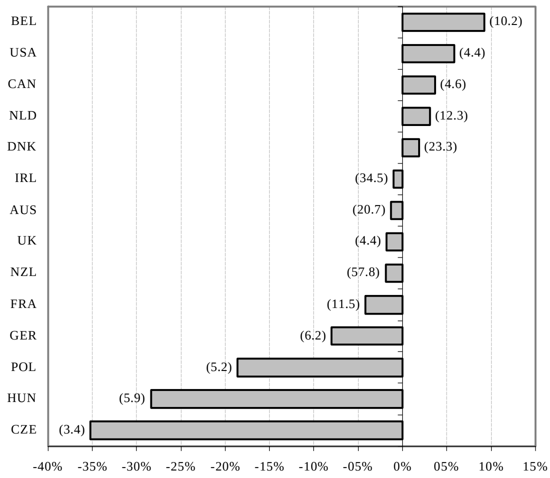
Pesticide use in agriculture
(% change 1986-88 to 1994-96)



Notes:
(..) Total use of pesticides in tonnes of active ingredients 1994-96, except Canada 1994.

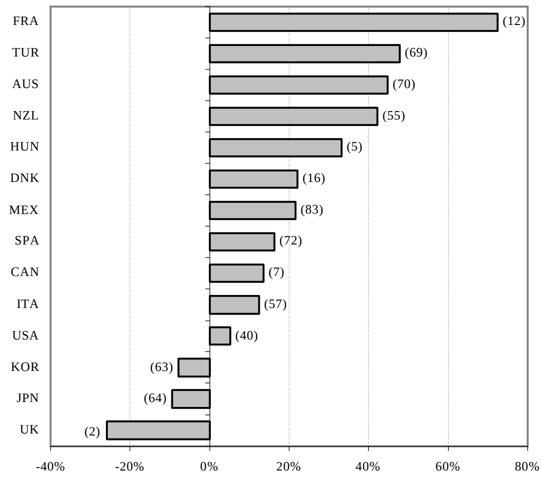
* Total use of pesticides in tonnes of active ingredients 1994-95.
Source: OECD, Environmental Database.

Gross emissions of greenhouse gases from agriculture
(% change 1990-92 to 1993-95)



Notes:
Gross greenhouse gas (GHG) emission data (excluding GHG sinks) covers the main agricultural GHG gases-- carbon dioxide (CO_2), methane, nitrous oxide-- converted to CO_2 equivalent using Global Warming Potentials for 100 years.
(..) Share of agricultural gross emissions in total gross emissions 1993-95.
Source: OECD Agri-environmental Indicator Database.

Irrigated agricultural land area
(% change 1980-82 to 1994-96)



Notes:
(..) % of irrigation water for agriculture in total abstractions 1995, except Italy 1980, Australia 1985, Canada and United States 1990.

Source: OECD, Environmental Database.

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