STATISTICAL COMMISSION and ECONOMIC COMMISSION FOR EUROPE

COMMISSION OF THE EUROPEAN COMMUNITIES

CONFERENCE OF EUROPEAN STATISTICIANS

EUROSTAT

Joint ECE/Eurostat Work Session on Methodological Issues of Environment Statistics
(Ottawa, Canada, 1-4 October 2001)

WORKING PAPER No. 21

ORIGINAL: ENGLISH

AGRI-ENVIRONMENTAL INDICATORS TO DESCRIBE AGRICULTURE SUSTAINABILITY

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Abstract: Assessing sustainability of human activities several aspects need to be taken into account, such as, on the one hand, the temporal and spatial dimensions, on the other hand, the social, economic, environmental and institutional dimensions and the correlations between them.

This paper will focus on agri-environmental indicators related to agricultural practices, whose data have been collected through the farm structure survey. In fact these kind of indicators can be used to point out progresses towards sustainability achievement, showing whether new and more sustainable production systems are applied in field.

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1. From agri-environmental indicators to the assessment of agriculture sustainability

Indicators represent a powerful tool to measure and/or simply describe specific issues at a specific state or in a dynamic frame. The *Driving forces, Pressures, State, Impacts and Responses* framework has been basically widely adopted to describe relationships between human activities and environment. The principle behind it is that any activity represents a flow of energy or material within the system whose effect can be seen as depletion of natural resources. While *Pressure*, *State* and *Impact* components reflect the physical part of the framework, *Driving forces* and *Responses* are more deeply linked to the human resources, the first one being related to the decisions taken on how to carry out a productive process and the second one to the reactions from consumer, producer and other actors of the agri-food chain (for agriculture sector), and moreover to the new public policy, to the financial instruments and to market responses.

Agri-environmental indicators have been implemented according to this scheme as shown in figure 1.

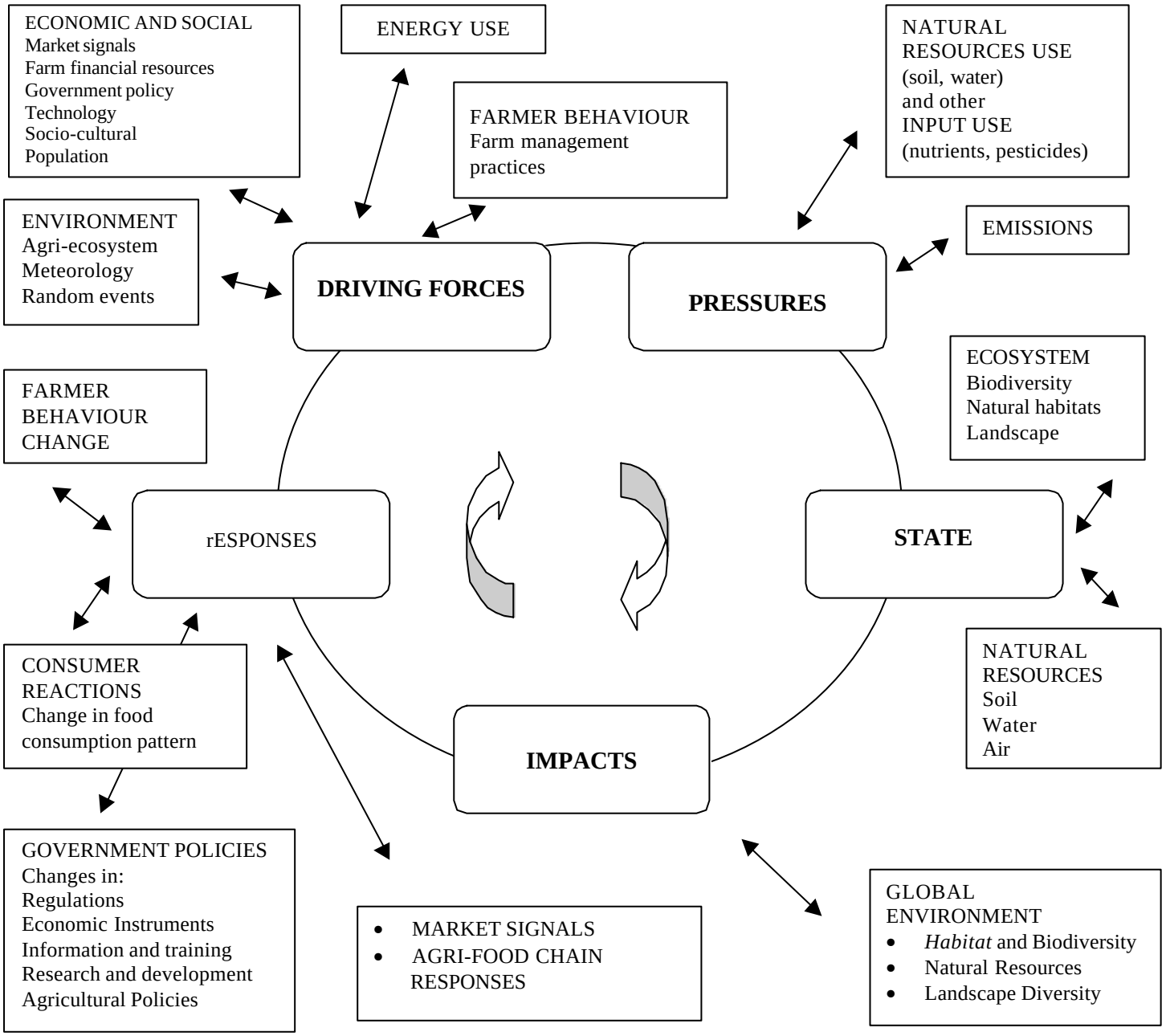

Figure 1 – D.P.S.I.R. framework for agricultural activity

Source: Modified from "OECD, 1997. *Environmental Indicators for Agriculture*, Publications Service"

DPSIR framework is more suitable for environmental issues and its circular nature it's useful especially to highlight data gaps. Moreover can be used to organise the information available in a dynamic way since one circle starting from driving forces can determine responses in a way that a new and quite different circle can be initiated.

Environmental sustainability for a specific sector could be actually assessed through calculation of indicators classified according to this scheme but the complexity of this topic requires a specific approach, in which the social, the economic and the environmental dimensions have their own role. In fact, as the UN Division on Sustainable Development stated, *sustainable development aims at social and institutional development, maintaining ecological integrity and ensuring economic prosperity* (UNDSD, 2001).

Beyond these aspects, the territorial level of the phenomenon observed is becoming more important, due both to the growing international integration of different countries and to the transboundary nature of negative or positive environmental effects of human activities.

The UN Commission for Sustainable Development and the countries involved agreed that the DPSIR framework is not appropriate for the social, economic and institutional dimensions of sustainable development and decided to shift to the *theme approach*, taking into account the four dimensions, each one of them related to political issues.

It is well known that agriculture sector plays a critical role to achieve food security and to support social and economic development and the maintenance of "rural lyfestiles", so that for this sector the four dimensions are strictly linked together. On the one hand agricultural production cannot be sustainable in economic and social sense without being sustainable in ecological sense, on the other hand poverty is widespread among rural areas where often for this reason subsistence agriculture is practised with the consequent natural resource depletion.

Natural resources need to be in *good* state in order to achieve food or feed production in the long term and sustainable rural development must be planned according to an integrated approach, taking into account all kind of effects on the mentioned dimensions.

Agenda 21 also remarks the importance of an holistic approach using an integrated, ecosystem-based management to achieve sustainable development of the land resource.

Nowadays production and consumption patterns can deplete quality and quantity of resources compromising the possibility to use them in the future, given the prevailing technologies.

These processes can be affected by decision-makers in several ways:

- implementing national and international institutional system to issue laws to protect the environment;
- implementing ways to measure and monitor progresses towards sustainable development;

- developing and spreading new and more sustainable technologies through research and extension programme;
- transferring technologies through economic incentives;
- internalising environmental negative effects into prices;
- growing the public concern on more sustainable alternatives and awareness on social, economic and environmental impacts of different consumption patterns;
- labelling products which are sustainable in social and environmental terms.

Quite often political issues focus on these topics so that it's quite important to find indicators to monitor and describe them. According to the DPSIR scheme, we could classify all these indicators as *driving force* or *response indicators.*

2. Agri-environmental indicators on farm management practices from farm structure survey

Since DPSIR framework has been implemented, international organisms, such as OECD (OECD, 2000), focused their attention on driving force indicators, that need to be more deeply investigated for their political relevance. Within agriculture sector they can be identified with farm management practices. These are responsible of increasing pressure on the environment but they can also be a necessary tool to mitigate land degradation factors. In fact, it is possible to state that agriculture contributes to the conservation of the countryside, as stewardship of the land resources.

The Farm Structure Survey (FSS) seems to be one of the main tool to collect data for agri-environmental indicator calculation. The FSS is conducted every year at Istat in accordance with EU precision standards on structure and production of agricultural holdings. Data are available at NUTS2 level. Through it information on holdings such as land use and crop production, livestock and dairy farming products, machinery use and labour force is collected.

In 1998 this survey was carried out to investigate issues related to *Environment and territory*, such as, among others, farm management aimed at specific practices related to soil, nutrients, pests and irrigation(Istat, 2001).

These indicators are useful to point out progresses towards sustainability achievement. In fact indicators on driving forces can show whether new and more sustainable production systems aimed at reducing pressures on the environment are applied in field.

Positive or negative picture, coming out from indicator calculation, can be attributed to the farmers, but more likely they might depend on the general context. In fact investment in research for sustainable agriculture, extension programme, farmer awareness, specific subsidies and consumer demand can drive farmer decisions.

As mentioned before, the survey conducted in 1998 covered the following issues:

- soil and land management;
- irrigation technology;
- nutrient management;
- pest management.

These issues have been chosen because soil and water are limited natural resources involved in agricultural production process and when their management, coupled with nutrient and pest management, is sustainable their depletion due to overexploitation and pollution is drastically reduced.

Soil and land management

Soil can be affected by degradation and *phenomena* such as compaction, erosion, fertility decline, loss of biomass and soil biodiversity can take place, desertification being the extreme consequence. Soil management mainly affects its physical structure and biological properties and being farming activity the main user of land, it is possible to state that a sustainable soil management within farms can play an important role in soil degradation prevention.

Talking about soil and land degradation the Convention to Combat Desertification (CCD), entered into force in December 1996, must be considered. The Conference of the Parties (COP), which is the Convention's supreme body, has held four sessions so far pointing out each time priorities and critical areas. Moreover causes and consequences have been highlighted in order to implement adequate site-specific strategies to combat desertification. The signatory countries, Italy being one of them, must prepare their national action plan and implement related activities.

Taking into account international debate on soil and land management, Istat in 1998 investigated with the survey several practices such as tillage, considered to be the main factor leading to soil compaction and erosion, crop rotation scheme, knowing that monoculture brings nutrient loss and erosion risk, burning crop residues, responsible for loss of biomass and fertility decline, while green manure and mulch practices can help to establish opposite trends.

Correlations with land tenure and equity in land access have been highlighted (socio-economic dimension), while many links to other environmental sub-themes can be described such as soil quality, desertification process, fertilizer use, water pollution, climate change (because of CO_2 emitted from burned crop residues) as well as to the economic dimension for reduced energy use (because of fewer tractor passes).

Available indicators

International organisms discussion on soil management is still under way and Istat proposed to keep into account some indicators beyond the ones already defined at international level:

- agricultural land by kind of tillage and number of passes (% of UAA);
- arable land under crop rotation, crop shift or monoculture (% of arable land);
- agricultural land under land management such as green manure use and mulch use (% of UAA);
- farms using crop residue burning practice (%).

Nutrient management

Agricultural practices disturb the agricultural systems causing nutrient loss, in fact the connection between nutrient release and absorption becomes less tight than in natural systems making nutrients more susceptible to volatilisation, leaching or erosion.

The main nutrients, nitrogen and phosphorus, can threat water and air quality. Usually leaching nitrates are responsible for ground water pollution, urea from synthetic fertiliser or animal manure is rapidly hydrolysed to ammonia, which easily volatilises, while phosphorus can reach water through run-off.

In terms of sustainability the main goal should be to reach a higher efficiency of nutrient use coupled to the increasing use of native available nutrients, such as biologically fixed nitrogen, or of on-farm produced nutrients, such as crop residues or organic manure coming from livestock.

At the same time, the use of a nutrient management plan can help to apply a correct amount of nutrient with a correct timing of spreading in field.

Talking about manure use, it is important to know whether farmers use organic manure and which type (dung, slurry manure, compost) they use. In fact different forms of nitrogen contained in dung and slurry manure, for instance, have different fate into the environment.

Decreasing losses and erosion results in reduced fertilizer use (environmental dimension), which in many cases can help trade balance (economic dimension) if fertilizer is imported, and in decreased water pollution risk (environmental dimension) and increased safer drinking water availability (social dimension); reuse of crop residues and animal manure reduces waste generation and consequent management cost (economic dimension).

Available indicators:

- farms applying a nutrient management plan (%);
- agricultural land fertilized with organic manure by kind of manure and quantity applied (% of UAA) (type of manure: dung, slurry and liquid manure, compost).

Irrigation Technology

Processes in economic activities and domestic use represent the main factors for surface and groundwater abstraction. Overexploitation of this resource can lead to lowering of groundwater table and often to water salinisation, which, in turn, is responsible for crop yield decrease.
Irrigation water in many arid and semi-arid areas is a vital resource to increase productivity, to extend the crop growing season or to shift to a more valuable crop production.
Different irrigation technologies have different efficiency rate (amount of water that reaches the crop on the quantity introduced into the farm irrigation system).
The efficiency rates for the irrigation systems investigated are the following:

- 40-50% for flooding and flow through channel system,
- 60% for aspersion system,
- 90% for low pressure sprinklers and drip-emitters.

The amount of wasted water is correlated to the type of irrigated crops, to the water supply need as well as to the extension of the system applied.
Increasing water use efficiency can reduce water withdrawal and maintain water quality (environmental dimension), while, in terms of links with other dimensions, it is possible to mention the correlation with the drinking water availability (social dimension) and with the energy use (economic dimension). Research and extension programme need to be implemented to ensure appropriate technology development and transfer (institutional dimension). In case of water trading, also trade balance needs to be taken into account.

Available indicator:
irrigated crops with different irrigation technologies applied (% of UAA irrigated) (type of irrigation system: flooding, flowing, aspersion, micro-aspersion, drip-emitters, other).

Pest Management

Integrated Pest Management (IPM) and Biological Crop Protection Method (BCPM) are increasing in several countries, since farmers receive subsidies and technical assistance for it. Both methods can reduce pesticide use at farm level.
In terms of sustainability, decreasing pesticide use (environmental dimension) in field:

- can help to relieve trade balance if pesticides are imported and decrease related waste generation (economic dimension),
- can decrease health risk associated to pesticide production and distribution (social dimension),
- can reduce air, water and soil pollution risk (environmental dimension).

Availability of appropriate IPM or BCPM at local level depends largely on expenditure on specific research and extension programme (institutional dimension).

Available indicators:

- agricultural land, by kind of land, under BCPM (%);
- agricultural land, by kind of land, under IPM (%) (type of land: arable land, permanent crop land, permanent grassland).

3. Conclusion

Development of appropriate approaches to sustainability assessment could be directed towards integration of new issues both at territorial level and at economic sector level. In this context statisticians can play an important role supporting the complex process by building a suitable framework, defining indicators, highlighting priorities and developing appropriate statistical methods.

In fact the indicator core set developed at international level by UNDSD need to be integrated at national level, according to a bottom-up approach. At national level specific issues can be highlighted and more appropriate indicators implemented. Moreover integration between territories, both intra-national and trans-national, should be analysed and pointed out also through indicator implementation.

More efforts need to be made by statistician also integrating new issues at economic sector level. Finding relationship between a specific dimension and the other ones would be a central task to carry on. Analysis of the observed effects in relation to changing policies can help implementing a more appropriate and sustainable development plan for the future. In fact integration between different sectoral economic policies, on the one side, and environmental and social policies, on the other side, need to be further developed and put in place. Appropriate statistical methods need to be implemented for this purpose.

For National Statistical Institutes integrating new issues into existing data collection tools, such as surveys on economic sectors and demography, represents a powerful way to implement good quality statistics at reasonable cost. In this context, Farm Structure Survey can be one of the main instruments to collect data on agri-environmental practices enabling us to calculate related agri-environmental indicators. Defining which issues can be addressed through the survey, statisticians and sector specialists have to take into account the overall framework.

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