Texte 42/99

Development of indicators for the assessment of agricultural impacts on the environment

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Short version

This report summarises the results of a project commissioned by the Federal Ministry of Environment, Nature Conservation and Nuclear Safety and co-ordinated by the Federal Environmental Agency. Contractor was the Institute of European Integration Research e.V.. The project has been carried out in an interdisciplinary approach as a co-operation between the Institute of Agricultural Botany, the Institute of Organic Agriculture, and the Institute of Agricultural Policy of the University of Bonn.

The aim of this study is to develop a set of indicators that could be continously used for a national environmental monitoring which focuses on specific agri-environmental effects.

Starting point was the identification of relevant agricultural impacts on the environment. There are different approaches to define and describe environmental effects: activities (e.g. fertilizing), medias of the environment (e.g. water), and environmental problems or impact categories (e.g. eutrophication). In this report the approach of defining impact categories is used. These categories were selected by comparing several surveys on agricultural and generally important environmental effects.

In addition, the agricultural responsibility for environmental effects was considered by identifying the sectoral contribution (e.g. the agricultural contribution to the national global warming potential). As a result 15 impact categories were selected which take into account all important environmental impacts of agriculture (Table 1).

Table 1:   Important environmental impact categories of agriculture

Impact categories
1.   Biodiversity
2.   Landscape image
3.   Soil function (soil protection)
4.   Drinking water quality (Drinking water protection)
5.   Eutrophication
6.   Acidification
7.   Ecotoxicity
8.   Human toxicity
9.   Global warming potential
10. Resource depletion
11. Odour
12. Animal welfare
13. Diversity of cultivated plants and livestock
14. Ozone depletion
15. Use of genetically manipulated organisms

Proposal of indicators

In the next step the indicators to measure the 15 selected environmental impacts have been defined to create a national monitoring-system. The indicators have been evaluated with respect to the following questions:

- Is it necessary to vary the indicator with regard to space and time?

- Do standards of the indicator exist to interpret the results, such as limit values or environmental quality targets?

- What are the relevant data resources?

- What efforts are necessary to implement the indicators?

- Which problems have to be overcome to implement the indicators?

As a result a set of indicators for the 15 selected impact categories was presented. The indicators have been classified following the Pressure-State-Response-Approach developed by the OECD.

An assessment of the expected effort by implementing the indicators and the needed further research is given as a relevant information for the responsible political institutions.

Table 2 summarises the proposed indicators.

Table 2a: Summary and assessment of the proposed indicators

Environmental impact categories	Proposed indicators	Effort of implementation	Needs
1. Biodiversity	State: Presence and population size of key farmland species	large	need of further research and new data gathering
	State resp. Pressure: Area with importance concerning nature conservation (margins, hedges, agricultural land under commitment to environmental conservation, semi-natural biotopes) and their cross-linkage	little up to medium	analysis of existing data and new data gathering
	Pressure: Intensity of land use (nutrient balance, pesticide management, share of grassland, intensity of grassland use, livestock density)	little up to medium	analysis of existing data, partly need of further research and new data gathering
2. Landscape image Degree of naturalness	State: Area and distribution of natural and semi-natural biotopes	medium up to large	analysis of existing data, and new data gathering
	State: Area and distribution of cultural features of agricultural landscape	medium up to large	new data gathering
Diversity	State: Scale of fields and areas of transition from field to field	little up to medium	analysis of existing data, and partly data gathering
	State: Numbers of crops and their distribution in the agicultural landscape	little up to medium	analysis of existing data, and partly new data gathering
Characteristics	State: Number of characteristic and visually valuable landscape components	Large	need of research and new data gathering
Harmony	State: Integration of farms into the landscape	large	need of research and new data gathering

Table 2b: Summary and assessment of the proposed indicators

Environmental impact categories	Proposed indicators	Effort of implementation	Needs
3. Soil functions			
Compaction	State: Use of the permanent monitoring plots	large	new data capture
	Pressure: Further development of simple soil management practice indicators		partly in need of further research
Erosion	Pressure: Assessing the potential of erosion (t/ha) on a scale of 1:25.000 on the basis of the Universal Soil Loss Equation (USLE). Degree of soil cover	medium	partly new data gathering and need of further research
Organic matter content	State: Use of the permanent monitoring plots. The transmission of existing methods to calculate the soil organic matter balance has to be proved	large	new data gathering and partly in need of further research
Accumulation of toxic substances in agricultural topsoils	Pressure: Description of the heavy metal input with sewage slurry and other urban biomass wastes on a regional scale. Supplementation by other toxic substances is possible	little	analysis of existing data
4. Drinking water quality	State: Results of the waterworks about the contents of pesticides and nitrate in the drinking water and the ground water. Pesticide contents in surface waters	little	analysis of existing data
	Pressure: Intensity of pesticide use (amount), N balance (PARCOM-Approach), area without pesticide use, length of permanent covered margins aside the bank.	little	partly new data gathering
	Enquiry on the implementation of the integrated plant protection management on a regional scale	large	need of further research and new data gathering
5. Eutrophica-tion	State: Results from the *measuring points* of the surface and ground water concerning N and P. N deposition from agricultural sources. Eutrophication of forest soils referring to critical loads	Little	analysis of existing data
	Pressure: Development of an ammonia emission indicator. Enquiries on a regional level. N and P surplus (after PARCOM), length of permanent covered margins aside the bank	little up to large	partly in need of further research and data gathering
6. Acidification	State: N deposition from agricultural sources. Acidification of forest soils referring to critical loads	little	analysis of existing data
	Pressure: Development of an ammonia emssion indicator. Enquiries on a regional level	large	partly in need of further research and data gathering

Table 2c: Summary and assessment of the proposed indicators

Environmental impact categories	Proposed indicators	Effort of implementation	Needs
7. Global warming potential	Pressure: Emissions of methane and dinitrogen oxide. The Federal Department of Agriculture and Food should improve its statistics concerning carbon dioxide emission	little	analysis of existing data concerning CO_2
8. Resource depletion	Pressure: Use of primary energy, use of phosporus and potassium in mineral fertilisers and feed supplements. Nutrient efficiency of N, P und K. Import of feeding stuff	little	analysis of existing data
9. Ecotoxicity	Pressure: Use of pesticides (amounts), use of feed additives and medicines in animal production	little	analysis of existing data
	In addition, the ecotoxicity of the single pesticides should be evaluated	medium	need of coordination: Evaluation with existing methods
10. Human toxicity	State: The pesticide content has to be considered in the existing environmental survey (of food) and the report about drinking water quality	little	analysis of existing data
	Data from the food monitoring programme should be included	medium	
11. Odour	State: The appropriateness of the indicator ammonia emission has to be proved, using inspections on a regional scale	medium	partly in need of further research
12. Animal welfare	Pressure: Evaluation of housing conditions (for cattle and pigs) concerning animal welfare. The use of existing methods is proposed. An approach to generate samples has to be developed	large	need of further research new data gathering
	Share of different kinds of housing conditions in poultry keeping (e.g. free range keeping, battery keeping)	little	partly new data gathering
	Indicators of transport and slaughtering: losses of livestock during the transport, share of modern slaughterhouses and livestock transporters	little	partly new data gathering
13. Diversity of cultivated plants and livestock	State: Survey on the endangered cultivated plants and livestock species and variaties	little	analysis of existing data
	Response: Measures to conserve endangered cultivated plants and livestock species and varieties	little	
14. Ozone depletion	Pressure: Amount and agricultural share of the emissions of dinitrogen oxide	little	use of existing data
15. Use of genetically manipulated organisms	Pressure and State indicators are actually not describable		
	Measures of monitoring could be used as response indicators	little	

Furthermore, allready existing approaches in Germany and the possible integration of the proposed indicators are discussed. This information might be important concerning the political application of the presented indicators by gains due to synergy effects.

RAUMIS

The economic sector-model RAUMIS, developed at the Institute of Agricultural Policy of the University of Bonn, provides several indicators to describe agricultural impacts on the environment, e.g. mineral balances or the calculation of greenhouse gases. The appropriateness of the model RAUMIS to contribute to an environmental monitoring was proved. Some potentials of improvement have been discussed.

Systems of national accounts

Two approaches are used to describe the environmental effects on the national and international level. Besides the exclusive environmental monitoring, several projects are striving for the integration of environmental effects into the existing system of national accounting. Different approaches have been discussed. Emphasis was put on the „Environmental-Economic Accounting„ (Umweltökonomische Gesamtrechnung) of the Federal Statistical Office.

The existing indicators of the Environmental-Economic Accounting have been evaluated concerning the incompleteness on the basis of the own proposed indicators. The statistical approach of the „Ecological sample survey„ (Ökologische Flächenstichprobe) could be a useful framework to describe biodiversity via direct indicators. In this report this approach has been analyzed with specific respect to the consideration of the agricultural sector.

Conclusions

Finally, an evaluation of the actual national environmental monitoring has been given. The need of further research to complete the monitoring is summarised (Table 3): some environmental impacts are hardly considered, especially those which are caused primarily by agriculture like biodiversity, landscape image, soil functions and animal welfare. The main emphasis of the previous environmental monitoring concerning agriculture is put on nutrients and greenhouse gases.

Table 3:   Degree of consideration of the proposed indicators for agriculture in the existing environmental monitoring

Environmental impact categories	Consideration in the previous national environmental monitoring
1. Biodiversity	partly
2. Landscape image	partly

3. Soil functions
        Compaction
        Erosion
        Organic matter
        Input of toxic substances
	
	no
	no
	no
	no

4. Drinking water quality	partly
5. Eutrophication	partly
6. Acidification	partly
7. Global warming potential	mainly
8. Resource depletion	partly
9. Ecotxicity	partly
10. Human toxicity	mainly
11. Odour	no
12. Animal welfare	no
13. Diversity of cultivated plants and livestock	no
14. Ozone depletion	yes (indirect)
15. Use of genetically manipulated organisms	no