Experiences with the evaluation of agricultural practices for EU Agri-Environmental Indicators

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Introduction

Since the early 90's the new “Common Agricultural Policy” (CAP) of the European Union was underlying a change of paradigm. In the face of growing environmental problems caused by an intensification of agricultural land use the European Community integrated environmental concerns in agricultural policy by diverse resolutions like the first Agri-Environmental programmes implemented under EU-Regulation No. (EEC) 2078/92 in 1992. They were followed by a continuous discussion about environmentally friendly farming systems opening out into the "Direction towards sustainable agriculture" (European Commission 1999). Parallel the OECD initiative about Agri-environmental Indicators (AEI) focussed on the development of an environmental measuring system as a policy supporting tool. The OECD (1997) launched the Driving Force - State - Response (DSR) model and a catalogue with 14 AEI areas, which should enable decision-makers on all levels to

- recognize and value impacts degrading the environment,
- assess future sources of danger and
- develop sustainable land use systems.

In this line the European Commission (2000) published "Indicators for the Integration of Environmental Concerns into Common Agricultural Policy" and "Statistical information needed for Indicators to monitor the Integration of Environmental Concerns into the Common Agricultural Policy" (European Commission 2001).

Research and development activities accompanied this phase about AEI with projects like:

- Land Use / Cover Area Frame Statistical Survey (LUCAS, 2001 – 2003, Eurostat 2003),
- Technical Action Program to Improve Agri-environmental Statistics (TAPAS, Europäische Kommission 2001)

Conclusions of diverse research projects are meanwhile drawn and led to the integration of agri-environmental issues even on the statistical level of the EU, e.g. tillage systems, erosion prevention, irrigation or linear landscape structures are on the way to become elements of the Farm Structure Survey (FSS) of the European Union (Eurostat 2006).

The selection of single AEI even for statistical surveys on EU level is a result about the demands on indicators, which go into a multitude of details about their attributes (Tab. 1). The development of AEI was mainly driven by scientists who are naturally interested in the scientific details but not necessarily in the political relevance and applicability of AEI. The Application of indicators in the field of policies mainly tackles reporting of environmental
impacts of agriculture, international comparability of data, use of AEI for development strategies, feedback on political regulations and evaluation of progress in the development of sustainable land-use (Tab. 2).

**Table 1: Demands on indicators.**

<table>
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<tr>
<th>Agri-Environmental Indicators should have the following attributes:</th>
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<tr>
<td><strong>Scope of indicators</strong></td>
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<td>- inform about status and development of complex systems</td>
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<td>- provide sufficient information about sustainability of land use systems</td>
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<td>- be responsive to changes related to human activities to indicate rapidly success and failure of activities</td>
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<td>- able to show trends over time</td>
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<td>- work as umbrella indicators summarizing different processes and/or environmental impacts</td>
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<td><strong>Policy relevance</strong></td>
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<td>- provide a representative picture of environmental, agricultural and rural conditions, pressures or society's responses;</td>
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<td>- be simple and easy to interpret for different users</td>
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<td>- provide a basis for regional, national and international comparisons;</td>
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<td>- be either national in scope or applicable to regional issues of national significance;</td>
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<td>- assist individual decision-makers of the private sector as well as trade and industry</td>
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<td><strong>Analytically sound</strong></td>
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<td>- be theoretically well founded in technical and scientific terms;</td>
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<td>- be based on international standards and international consensus about its validity;</td>
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<td>- lend itself to being linked to economic models, forecasting and information systems</td>
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<td><strong>Measurability and data required</strong></td>
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<td>- have to be controllable</td>
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<td>- readily available or made available at a reasonable cost/benefit ratio;</td>
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<td>- adequately documented and of known quality;</td>
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<td>- updated at regular intervals in accordance with reliable procedures</td>
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<td>- have a threshold or reference value against which to compare it, so that users are able to assess the significance of the values associated with it</td>
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**Table 2: Application of indicators in the field of policies.**

- Agri-environmental reports
- International comparability of environmental concerns
- National and global development plans and development strategies
- National feedback on international regulations, conventions and environmental initiatives
- Evaluation of progress in the achievement of environmental goals

Summarizing the indicators should lead scientists to simplify complex environmental issues, fulfil the requirements of policy makers for monitoring policy impacts and
informing decision making, and give advice to local communities for awareness raising and agenda setting.

The UN Commission on Sustainable Development explained that “High-level decision makers (government ministers, foundation executives and heads of corporations) routinely ask for a small number of indices that are easy to understand and use in decision making” (CSD 2001). Under these headings agricultural practices and management of arable land on EU-15 level was analyzed to find out which kind of indicators are informed by statistical surveys or individual national or regional available data. In a first step restrictions in the application of indicators had to be envisaged to prevent the evaluation of dead-ends (Tab. 3).

Table 3: Restrictions in application of indicators.

Restrictions in application of Indicators
- different availability of data and information on the national and international level
- lack of methodological standards in the international context
- different ranking of indicators on the international level and therefore different legal treatment, what leads to imbalance in the international valuation
- lack of thresholds, basis figures or reference levels, so that often no orientation is given whether trends in the environmental development are strong or weak, e.g. as for biodiversity
- spatial relation is not sufficiently considered. On the international scale the use of average values on the country level is widespread, so that regional environmental loads are neglected
- several indicator issues overlap so that an overestimation of single parameters is likely to be expected
- long-term monitoring programmes are necessary to realize long-term environmental changes
- indicator development is dominated by measurable parameters which distracts from those impacts dealing with non quantifiable values like aesthetical, ethical or cultural values
- lack of models which could bridge information deficits
- application of models without realizing the limits and deficits of models under others because of a lack of information
- lack of priority setting of indicators so that a ranking of strategies for the enhancement of sustainable land use of agricultural landscapes is not yet possible on the basis of agri-environmental indicators

Exemplary two kinds of AEI are presented in the following to illustrate their power on the one hand or the problems of data deficits on the other hand. Afterwards conclusions on the further work on policy-relevant AEI will be drawn.

Farm management practices soil cover and tillage as AEI

Based on the PAIS project, soil cover and tillage systems were worked out as part of the IRENA Indicator fact sheet N° 14: Management Practices (Piorr & Eppler 2005, Eppler & Piorr 2007). Farm management practices are defined as the decisions and operations that shape the practical management of farms, such as cropping methods, soil cover and tillage. Only limited data is available at farm level about cultivation methods except for few countries or regions.
Furthermore site-specific agricultural and environmental conditions impact farmers’ behaviour. Farm management practices can vary from one region to another and even between farms in the same region though site characteristics in a natural spatial unit force farmers to operate in a somehow uniform way. Main farm management practices are given with the choice of crops and the tillage system. E.g. to minimise soil erosion farmers have to decide whether to cultivate a crop like maize or sugar beets with a high erosion risk and whether to reduce the erodibility by a no-till and mulch-till practice.

Where the links between farm management practices and the environmental effects of farming are well known, the monitoring of farm management parameters can provide an early indication of likely changes in environmental impacts from farming before these are measurable by other indicators, such as those on soil and water quality. Tracking farming practices can therefore provide earlier and complementary knowledge than through measuring actual changes in the environment. Information on farm management practices is very relevant for several other agri-environment indicators, such as those on nutrient balances, soil fertility, soil erosion, water contamination by nutrients and pesticides, good farming practices etc. Information on farm management practices, how these practices affect the environment, and whether they correspond to recommended (or legislated) practices and standards can therefore contribute to supporting agricultural policies.

**AEI Soil Cover on arable land on EU-27 level**

The soil cover parameter was calculated on the basis of data on the distribution of arable land under different crops provided by the Farm Structure Survey (FSS) and by using index values of period of soil coverage for different crops.

In the year 2005, the average share of soil cover by the main annual green crops ranged from 11 % to 80% of EU-27 arable land area. A low soil cover, with less than 30 % coverage in the year, is observed in the northern countries like Estonia and Finland, the northern parts of Sweden, in the north of Portugal and on the Italian and Greece islands. In some regions of Italy (Lombardia), Spain, France (Alsace region), the Netherlands (Noord Holland), Romania, Hungary, north of Portugal and Austria a low soil cover is related to a predominance of maize. In some of these regions, more than 50% of arable land is cultivated with maize. A moderate coverage, between 50% and 75%, is found in Germany, Poland, Denmark, north of France, UK and Austria.

**Figure 1: Percentage of soil cover by green crops on arable land 2005 in EU-27 (Eppler & Piorr 2007).**

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1 Due to method change and because of data problems in the available statistics (time series for crops, break in definition of NUTS areas) it is currently not possible to describe any trends. But with the improved methodology in future it would be possible to generate time series and interpret describe trends.
Figure 2: Percentage of soil cover by maize (green and grain) on arable land 2005 in EU-27 (Eppler & Piorr 2007).
The IRENA indicator No 14.1 – Soil cover on arable land by green crops - measures the number of days in a year that the soil is covered with vegetation. The greater the cumulative soil cover, the less in-situ soil erosion occurs. In addition, less surface runoff is generated, and by the way erosion of soil by overland flow (thereby maintaining soil fertility) and the transport of soil, nutrients, pesticides and faecal microbes to waterways are reduced. This, in turn, decreases adverse impacts upon aquatic biodiversity. Figure 3 summarises the environmental benefits of soil cover.

The degree of soil cover provided by each crop depends on its growth period, its leaf area and how quickly cover is established after seeding. The equal distribution of crops or residues is the determining factor to measure the erosion risk. Summarising the effectiveness of any crop, management system or protective cover depends on how much protection is available at a given period during the year, relative to the amount of erosive rainfall that falls during that period.

Policy relevance and context
Sustainable soil management is an important policy target, because soil is essentially a non-renewable resource with potentially rapid degradation rates and extremely slow formation and regeneration processes. Furthermore, soil available for food production per person is limited. This highlights the importance of cultivation methods for the protection of the soil resource. The Sixth Environment Action Programme emphasises the need for an EU strategy on soil protection. Consequently, the Commission proposed the Thematic Strategy for Soil Protection [SEC(2006)620 + SEC(2006)1165] in early 2006. However, soil protection is also very relevant for other EU legislation relating to water, such as the Water Framework, Nitrates and Bathing Water Directives. In addition, soil protection also has a bearing on the objectives of the EU Habitats Directive via its impact on aquatic and terrestrial habitats.

EU rural development policy (Council Regulation No (EEC) 1698/2005) provides support for agri-environment programmes to encourage farmers to carry out environmentally beneficial activities on their land. The agri-environment measures include support for changes of land use, improvement of rotation patterns, support for organic farming, conservation tillage, the protection and maintenance of terraces, integrated crop management, etc. The reintroduction of environmentally beneficial arable rotations and use of perennial ley, where these have become uneconomic, is a feature of several programmes addressing mainly intensive arable production. Benefits accrue in particular to soil structure. On arable sites the use of winter cover crops, by undersowing, retention of stubbles after harvest, or by allowing weeds to grow, can lead to substantial reductions in winter nitrate-leaching. Minimum environmental management practices are also ensured via cross-compliance rules, as defined by EU Member States on the basis of Regulation 1782/2003.

Agri-environmental context

The soil, as basis for all agricultural activities, is the interface between agriculture and environment. However, serious soil degradation, which threatens the productivity of the different soils, can be observed everywhere in Europe (EEA, 2000). Soil degradation processes such as erosion, decline in soil organic matter, soil contamination, soil sealing, soil compaction, decline in soil biodiversity and salinisation can cause soil to lose its capacity to carry out its main functions (OECD, 2001).

Such degradation processes can result from inappropriate farming practices such as low soil cover over winter, unbalanced fertilisation, use of heavy machinery, or overgrazing. Soil degradation may also result from abandonment of certain farming practices, for example traditional crop rotation systems or manuring with green legumes, practices which contribute to the maintenance and restoration of soil organic matter content.

Hence, permanent soil coverage throughout the year should be the aim (OECD, 2001). Figure 3 gives an overview of the importance of maintaining adequate soil cover for different categories of environmental issues.

The monitoring of soil cover:

- gives valuable information about trends towards good farming practices,
• contributes information about likely soil fertility,
• provides significant information about the risks of nitrate leaching,
• provides significant information about erodibility of soils,
• could be improved by information about intercropping and tillage systems.

Figure 3: Environmental impact of soil cover on biotic and abiotic resources.

One limitation common to all of the described information sources with respect to soil cover is that none of them account for management practices such as the minimum till methods without ploughing. Such practices enhance soil cover, reduce the generation of surface runoff and increase the organic content of the soil. Information from agri-environment programs may be of relevance in this respect, but this is typically available from selected countries only (not EU-27) and only at national or regional scales. Consequently the soil cover investigations were followed by an evaluation of European tillage systems.

AEI Tillage system on arable land on EU-27 level

Tillage operations can affect the soil erosion risk, depending on the depth, direction and timing of ploughing, the type of tillage equipment and the number of passes. Generally, the less the disturbance of vegetation or residue cover at or near the surface, the more effective the tillage practice in reducing erosion (Boardman & Poesen 2006, Montanarella 2006).

Conservation tillage foregoes the use of ploughs (= soil tillage without ploughs). Instead, it uses tillage tools that do not turn the soil (such as cultivators or disc harrows) or disturb the structure of the soil and involves the leaving of crop residues (avoidance of burning) such as straw (mulch) near or on the surface of the soil. The aim is to substantially reduce the effects of soil erosion from wind and water (thereby also reducing the loss of agricultural
pollutants to waterways in runoff), minimise soil crusting, and to increase the organic matter content of surface soils.

Direct seeding is defined as cultivation without tillage after the previous harvest. Specific types of drills which open the sow-slots into which the seed is deposited are needed for this sowing method. Direct seeding can be seen as a special extension of conservation tillage since it also does not turn the soil. In contrast to conservation tillage, the soil is not cultivated for sowing with the exception of opening the sow slot.

Contrary to a good developed information system about soil cover there are few reliable data sets on the adoption of conservation practices (e.g. in France, where official statistic is available and where minimum tillage or direct sowing is part of AEP’s, like in some federal states of Germany or from associations for conservation agriculture, like Consortium Agriculture Ireland (CAIR)). The available data comes largely from the European Conservation Agriculture Federation (ECAF).

In Finland and the UK a considerable share (Finland 52.3% and UK 45.6% of UAA) of conservation tillage practice can be found. In Belgium, Germany, France, Czech Republic, Spain and Portugal a share of about 20% is documented. In Estonia remarkable 16% of conservation agriculture is observed. In Denmark, Hungary, Greece, Italy and Slovakia conservation tillage involves ca. 10% of arable land. However, conservation tillage methods are increasingly being adopted in most of the EU Member States (ECAF 2005/6; KASSA 2006).

The share of direct sowing, which is defined as soil cultivation without tillage, remains low in the EU-27. No-tillage is practiced on about 10% of the arable area in Finland followed by 7.4% in Greece and 4.5% in Spain. In Czech Republic, UK and Slovakia no till is used on ca. 3% of arable land, in Germany and Portugal on approximately 2% and in Italy and France on about 1% of UAA. In the other Member States for which data is available, less than 1% of direct sowing is recorded (Estonia, Hungary, Ireland).

Figure 4: Percentage of conservation tillage and direct seeding on UAA (Eppler & Piorr 2007).
Policy relevance and context

The Sixth Environment Action Programme emphasises the need for an EU strategy on soil protection. Both discussed AEI, soil cover and tillage system are tackled by Thematic Strategy for Soil Protection [SEC(2006)620 + SEC(2006)1165] in early 2006, as well as by other EU legislation relating to water, such as the Water Framework, Nitrates and Bathing Water Directives.

The bundle of measures which is addressed by EU rural development policy (Council Regulation No (EEC) 1698/2005) provides support for all soil protective activities. This counts for both support for improvement of rotation patterns and soil cover as for conservation tillage. One part of environmental management practices is regulated by cross-compliance rules (Regulation 1782/2003). The Member States are also obliged to provide advice on farm management via extension services.

Agri-environmental context

Tillage practices are an important factor influencing other indicators such as risk of nitrate leaching and the organic matter content of soils. Conservation tillage generally increases the organic matter content of soils and improves soil structure. A healthy soil structure prevents soil compaction, which reduces water infiltration capacity and increases erosion risk by promoting the generation of runoff.
Increased soil organic matter by minimum tillage also supports a richer soil biota that can improve nutrient recycling and this may also help combat crop pests and diseases. The greater availability of crop residues and weed seeds improves food supplies for insects, birds and small mammals. Figure 5 gives an overview of the relevance of conservation tillage for different environmental issues.

The monitoring of tillage systems:
- Provides insight into levels of soil fertility.
- Provides data on issues such as carbon-friendly farming.
- Provides information about the exposure of arable land to soil erosion and the risk of subsequent losses of nutrients and pesticides with water run-off.

Figure 5: Environmental impact of tillage practices with reduced or no tillage on biotic and abiotic resources.

Lessons learned

The AEI soil cover and tillage system are both multi-criteria indicators. They indicate a bundle of agricultural practices with high impacts on diverse environmental parameters. On the other hand the data availability about tillage systems is poor compared to soil cover where FSS data provide profound information about the share of crops on NUTS level 2/3. A simple GIS procedure combining the share of crops with phenological data reveals a rather precise overview about soil cover on arable land in EU-27. Together with site specific conditions like rainfall periods and elevation levels, the erosion risk can be predicted or hot spots of unprotected soils can be identified and be used for policy measures. The same counts for high shares of crops as exemplified with maize which is meanwhile dominating larger regions in European member states. Poor crop rotations with cultivation risks like crop
Rotation diseases can easily be identified. Properties of crops like contribution to soil organic matter – e.g. high with Lucerne, low with maize – give advice for the development of soil protective political measures.

In this context, the significance of tillage systems, working towards the same direction like soil cover, was recognized by the EU. The lack of data concerning soil cultivation methods will be solved. The next period of the Farm Structure Survey will be enriched by questions for tillage systems (Hubert 2010).

The next step for the valuation of agricultural management systems has to be the identification of natural spatial units with uniform agricultural productivity. This will enable policy-makers to value the productivity level and intensity of farming in relation to environmental conditions. First results on EU-27 level are meanwhile available using soil and climate data combining with long-term analyses of productivity levels of crops on NUTS 2/3 level (Piorr et al. 2009). Following this procedure, favourable sites for specific crops and their growing conditions can be identified. For political reasons non-site conform cultivation can be recognized and regulated.

Figure 6 gives an example for the selection of sites for maize growing in the Czech Republic to produce biomass for biogas plants. Restrictions for the productivity of soils, crop rotation, precipitation and slope of the fields were set and favourable sites and regions for the biogas production in a GIS procedure mapped.

**Figure 6:** Favourable sites for maize growing in the Czech Republic considering environmental restrictions (Piorr et al. 2009).

Concluding the ongoing development and implementation of AEI should consider that AEI
- have a high environmental significance which should be used for an AEI ranking procedure.
- are multi-criteria indicators which inform different environmental issues.
- are easy to understand for politicians and their voters.
- are based on available statistical information.
- can be easily extended (soil cover + tillage systems = soil fertility).
- can be generated on a low-budget level.

**Bibliography**


