Indicators for a Sustainable Development in Agriculture

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By Olaf Christen
and Zita O’Halloranetholtz

Preface

This English summary of a comprehensive scientific study has jointly been published by the Institute for Agriculture and Environment (ilu), Bonn, and the European Initiative for Sustainable Development in Agriculture (EISA), also in Bonn.

The Institute for Agriculture and Environment has been founded in 1997, and is part of the Association for the Promotion of Sustainable Agriculture (FNL), Bonn. Together with experts from different disciplines of the agricultural and environmental sciences, collections of data and facts, analyses, consultations and documentations are performed.

The European Initiative for Sustainable Development in Agriculture (EISA) has been founded in January 2000 by six national organisations from European Countries. EISA members are strongly committed to sustainable agriculture, which is economically viable, environmentally responsible and socially acceptable. EISA members will continue to work in partnership with all stakeholders to achieve this goal through the promotion and further development of Integrated Farming.

The principles and guidelines for Integrated Farming have been laid down in the EISA document "Common Codex for Integrated Farming" (published in January 2000). In this Common Codex, sustainable development and Integrated Farming are described as follows:

- **Sustainable development** on our planet cannot be achieved without a major contribution from agriculture. People must be fed, and agriculture is faced with the challenge of producing food for a rapidly growing world population whilst maintaining the world's fragile resources. Modern farming systems have evolved to meet this need in a way that combines the essential requirements of profitability and productivity.
- **Sustainable development** must encompass food production alongside conservation of finite resources and protection of the natural environment so that the needs of people living today can be met without compromising the ability of future generations to meet their own needs.
- **Integrated Farming** meets these potentially conflicting challenges at farm level, in a manner that balances food production, profitability, safety, animal welfare, social responsibility and environmental care. Integrated Farming seeks to reinforce the positive influences of agricultural production whilst reducing its negative impacts. It is a means of achieving a sustainable agriculture and an indispensable part (but only apart) of sustainable development.
- The **Codex** defines a set of common principles and practices that will enable farmers and growers to achieve these goals through the promotion and further development of **Integrated Farming**.

However, if sustainability is meant to be more than a rather general and non-binding concept, tools are needed to measure and judge ongoing developments, and to define clear goals to be achieved. In this context, indicators and indicator models have been presented and intensely discussed in recent years. It has proved to be difficult, though, to define such indicators for all economic, ecological and social aspects being an essential part of a sustainable development.

Even though some indicators are still not available, precise enough and/or generally accepted, this approach has proved to be a helpful tool for the management at farm level. Indicators allow the individual farmer to check his farming practices for weak spots, be it nutrient balances, energy efficiency or productivity for example. Most of the data needed for these indicators are easily available on the farms. There still is a lack of practical approaches in fields such as trace gas concentrations, the use of plant protection products, biodiversity and others. In general, a practical use of indicators on the farms seems to be promising, whereas it has to be emphasised that it has to be judged very critically if indicators are more or less – or even solely – understood as tools for political and administrative steering and control. The more indicators are aggregated into one set of data or one single figure, the less information can be derived and the less probability exists that this single figure truly presents the real situation – and allows according political action.

EISA understands the importance and the potential inherent to indicators and indicator models. EISA therefore presents this paper on the “state of the art” of indicators, highlighting their possibilities as well as their present limits, as an important contribution to the further development towards sustainable agriculture.

Executive Summary

Sustainable development, encompassing economic, ecological and social aspects, can only be achieved if appropriate methods for measuring these different components are available.

Today, there are a number of approaches to making sustainable agriculture measurable and thus implementable on the individual farm. However, only a few approaches have been tested for practicability in a larger number of farms or regions.

Conclusions and Recommendations

The concept of sustainable development integrates economic, ecological and social aspects. Sustainable development in agriculture can only be achieved if appropriate methods for measuring these different components are available. After extensive discussions on the supposedly best definition of sustainability or sustainable development in the agricultural context, there are now a number of approaches to making sustainable agriculture measurable by indicators and thus implementable *on the individual farm.* Criticism is due, however, when indicators are understood and used exclusively as political control mechanisms. As will be shown below, indicators, if employed indiscriminately, lose much of their information value, accuracy and thus usefulness.

A large number of indicator systems are available today which, in spite of some differences in detail, do have a lot in common. Based on the three key domains of sustainability - economy, ecology and social affairs - they are used to describe variables covering the status or influence of agricultural production.

To avoid misunderstandings and false interpretations, the presently existing indicator concepts should be systematised according to the following criteria:

- scale of observation (regional, farm and / or field level),
- purpose of the indicator system (optimisation at field, farm or regional level, administration or control),
- model bases (description of farm-internal material and energy flows with interactions between different cultivation practices and / or farming system components),
- regional reference (master data or modelling),
- transparency of evaluation and aggregation processes,
- cost of data acquisition,
- practical handling (PC solution or internet-based procedure).

Special attention should be paid to the different approaches' distinct differences of purpose. Basically, a distinction should be made between the purpose of optimising the individual farm and that of administrative control. Closely linked with this aspect is the question of how much effort will be needed for establishing the data base. In the case of scientific research several years (!) may be required, for simple approaches designed as administrative instruments a couple of hours will sometimes be sufficient. The concrete formulation of the indicator system will have to differentiate according to the purpose that is given priority. Regrettably, up to this day many of the suggested indicator systems have hardly been tried, if tried at all, and only few approaches have been tested for practicability in a larger number of farms or regions. As a consequence, the question of the required minimum number of individual indicators must at present be regarded as scientifically unsolved, and the effects of an inappropriate choice of indicators - i.e. the

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resulting mismanagement - must be pointed out very clearly. For the future, it is therefore very important that the different systems be actually implemented and their advantages and disadvantages with regard to the various purposes analysed in comparative studies. This will certainly not result in a single approach suitable for all situations and contexts. On the contrary: Depending on the objectives, the spatial frame of reference and, not least, the financial resources available for data procurement, various indicator systems will be more or less suitable. So there is, besides the apparent competition of different approaches, also a vast area of complementarity. And it is against this background that an - at least partially - co-ordinated course of action will be helpful to ensure a minimum of comparability of the different systems in important aspects.

Apart from these general recommendations and systematisation concepts, a critical look must be taken at the suitability of the individual indicators that have been suggested. Central questions in this respect are the reliability of the data base, the scientific backup, the suitability for modelling and a potential applicability of threshold values. The most important indicators must fulfil the following requirements:

- The **productivity** of different agricultural land uses, measured as the output per unit of area, should be regarded as a key indicator for assessing farming systems. The data base is sufficient at all scale levels. For an interpretation, however, information on the region-specific and, ideally, also the weather-specific yield potential is needed, which has to be gathered either in data banks or in yield models. Moreover, output levels can only be usefully interpreted if seen in connection with information on cultivation practices, in particular the level of fertilisation and the application of plant protection products. Such an approach is the only way to determine whether the ratio of output performance to input cost is adequate.
- **Rotation pattern** and **cultivation frequency** can be considered to be equally well-suited indicators at all scales of observation. A complex description by models is not required. Data procurement, scientific acceptance and interpretation of cultivation frequency are comparatively unproblematic. Both indicators can also provide information on biodiversity.
- **Genetic diversity** and **variety choice** can basically also be used as indicators for the assessment of sustainability. But in the indicator hierarchy, they must be seen in context with rotation pattern and cultivation frequency. Data acquisition may be more or less costly depending on the scale of observation, but it can be done on the basis of information provided by plot card indexes or by the agricultural trading community.
- **Nutrient or fertiliser balancing** is an important indicator for assessing the sustainability of agricultural production. Proper fertilisation is an essential condition for high productivity and crop quality. At the same time, fertilisation plays an important role in maintaining and improving soil fertility. The analysis of nutrient and fertiliser balances will also provide information on the develop-

Threshold values can be applied in principle to parameters such as productivity, rotation pattern and cultivation frequency, genetic diversity and variety choice, nutrient or fertiliser balance and energy assessment.

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ment of soil fertility and help to assess environmental impacts. In connection with the site and performance assessment, insights can thus be gained into the efficiency of nutrient inputs and the potential threat to the environment.

- The **energy assessment of farming systems** is a central parameter with good comparability and threshold applicability. The net energy gain and / or energy efficiency can be used as basic indicators for the energy assessment, the energy gain thereby serving in the first place to evaluate performance and the energy efficiency to evaluate the environmental impact of a system. The data base built on yield statistics and knowledge of production methods can be characterised as sufficiently precise at all scale levels. Just as in the case of the productivity indicator, however, detailed information on the region-specific yield potential - to be gathered either in data banks or in yield models - is necessary to interpret the data.

With the reservations described above, threshold values can be applied, in principle, to all parameters mentioned so far. It should be noted, however, that a reasonable interpretation will only be possible if the whole system is analysed and the interactions between different cultivation practices on the one hand and the site-specific yield potential on the other are sufficiently reflected.

- The **use of plant protection products** is an important indicator to assess the sustainability of agricultural production systems. The assessment is, however, complicated on account of the great complexity of this indicator and the difficulty of its evaluation. Problems of evaluation not only relate to dose and frequency of application, but are in particular due to the fact that there are hardly any models available to describe yield formation and disease development or pest infestation in context. First approaches towards assessing the risks involved in the use of plant protection products have been developed, but an accurate quantification is not yet possible in all cases.
- Modifications of whole land use systems or of individual cultivation practices can change **trace gas concentrations** in the atmosphere. Balance-neutral energy generation from biomass and carbon sequestration can be regarded as positive contributions in this respect. The impacts can be surveyed indirectly by monitoring changes in the soil carbon content and different parameters of the energy assessment. A more accurate assessment of the emissions of the climate-relevant gases methane and nitrous oxide is problematic, which means that for the time being threshold values cannot be specified for these parameters. Besides, current approaches tend to disregard agriculture's positive contribution with regard to carbon fixation.
- **Biodiversity** is unanimously considered to be an important parameter for assessing the sustainability of agricultural production systems or agricultural landscapes. But the use of biodiversity as an indicator is problematic as this term describes an extremely heterogeneous locational or regional situation.

The use of plant protection products, trace gas concentrations, biodiversity, soil properties, economic efficiency and the social situation of people working in agriculture have not yet been fully established for all scale levels and thus are still discussed in the scientific community.

To further develop individual indicators and indicator systems, as many processes as possible must be described in a system of agri-environmental models of high scientific quality. Basic research in this domain has to be intensified.

The data base must therefore be regarded as insufficient. Indirect indicators such as the share of landscape protection areas and priority areas for ecological restoration and land improvement or crop diversity are more appropriate. The data base for these indicators at different scale levels is better. If specific features that are typical of the region or the farming system are taken into consideration, even a limited potential for applying threshold values might be defined.

- **Soil properties**, like structure status and humus content, as well as soil modifying processes, such as erosion, compaction, puddling or salinisation, are important indicators for assessing the sustainability of agricultural systems. But the data base must be seen as altogether problematic. For cost reasons, specific measurements at farm or plot level can only be taken in exceptional cases, while normally simulations will have to be used. Relatively good forecast mechanisms are available for humus reproduction (humus balancing) on the basis of data derived from long-term tests. The erosion potential can also be assessed by using site and climate parameters in combination with information on cultivation frequencies, crop rotation patterns and specific countermeasures. The soil structure is another important indicator for the assessment of sustainability. Based on appropriate models, it is already possible to assess the risk of soil structure changes and compactions as a function of specific soil properties. This assessment can be used as a basis for recommendations on maximum machine weights, axle loads and / or application times.
- The **economic efficiency** of a farm can be described by calculating the profit of the different production processes, by establishing contribution margins and the optimum specific intensity. The data base at farm level can be considered to be basically good. At regional or national level, however, the identification of efficiency criteria is problematic. A specification of threshold values is only possible with reference to regional and farm-type-specific comparison data.
- For the assessment of the **social situation of people working in agriculture** a number of indicators have been suggested. At regional, federal state or national level, income distribution, welfare index as well as the share of persons employed in agriculture may be chosen. The data base is good and comparative approaches can be used to define threshold values. By contrast, a satisfactory solution for social indicators at farm level, such as income per person employed, level of education, further training facilities, etc., has not yet been found. The suggestions that have been put forward so far are scientifically disputed, and the acquisition of data would require considerable effort. It is therefore hardly possible to define threshold levels.

To further develop single indicators and indicator systems, as many processes as possible must be described in a system of **agro-environmental models**. The acceptance of such an approach will depend on the scientific quality of the models that are used. It is therefore necessary to intensify basic research in this domain and to check the various approaches against real data. The development of

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simulation models with a view to identifying sustainable land use systems is also requested by the advocates of an ecological economy. The major objective of such a development must be the forecast of system behaviour, that is to say of all the relevant interactions within the system. Indicator concepts that do not sufficiently reflect the interactions of different agricultural practices are inappropriate. But at the same time, care must be taken to maintain the practicability of the approaches. Moreover, a lot of research on single indicators remains to be done before the data can be used in models.

These reservations notwithstanding, it can be seen that the question of how to measure sustainable development has become a matter of great importance in many sectors of the economy and at very different scale levels. But it should also be borne in mind that in the case of agricultural land use, which is the subject of our reflections, current approaches consider, as a rule, only the risks and potentials that the pressure on the environment presents for natural resources. They focus on consequences such as erosion, deterioration of water quality, loss of biodiversity etc. But they disregard the fact that agriculture's primary responsibility is to supply food of high quality and in sufficient quantities to the population and raw materials for non-agricultural production, just as they disregard the indisputably positive aspects of agricultural production, such as energy fixation or, depending on the farming system, management of the cultivated landscape, etc. This approach is not in keeping with the present state of the discussion on the definition of sustainable agriculture, nor is it sufficient to constitute the basis for an informed discussion on the choice of adequate indicators. It is therefore necessary to insist that all indicator systems include, in addition to the hazard potentials, the positive effects of a certain operation or of selected practices on the various areas of the environment. This applies both to indicator systems which are used solely within the agricultural sector and to a wider range of approaches in very different sectors of the economy including industry.

A second important area where a considerable amount of research remains to be done is the aggregation of sub-indicators. In this area, there is still a great need for scientific discussion, and conclusive answers cannot be expected in the near future. For all scepticism as to whether an aggregation should be actually aimed at, one should not forget that a simple unit of measurement for sustainable development in agriculture is bound to facilitate the public and political discussion. This advantage must be weighed against the obvious disadvantages of information loss. Especially with a view to policy recommendations, the issue of aggregation must therefore be discussed with due care and attention.

For future developments in the field of agro-environmental indicators, the experience gained in the context of IPM (integrated pest management) leads to the conclusion that a well-balanced combination of scientific expert knowledge and pragmatic application at farm level will produce the best results. In the spirit of

On the basis of scientific findings, active participation of different segments of society in the further development of individual indicators and indicator systems will help to ensure wide acceptance.

Agenda 21, the further development of individual indicators and indicator systems should not be done by the scientific community alone, but with the active participation of other segments of society. A consensus on content and procedure will certainly not be reached in all cases, but an open discussion throughout the process of elaborating and testing the indicator systems will help to ensure wide acceptance. If sustainable agriculture is to gain prominence as a new guiding vision, a broad social dialogue will also be necessary. Only in such an environment can sustainable development advance and finally be used as a measure for assessing land use systems.

The authors:

Prof. Dr. Olaf Christen studied agriculture at the Christian-Albrechts-University in Kiel and achieved his doctorate there in 1990. Following a research sabbatical at the University of New England in Armidale, Australia, he returned as an assistant to the Institute of Crop Science and Plant Breeding at the University of Kiel in 1992. In 1997 he obtained his post-doctoral qualification in the field of Crop Science and has been employed as an associate professor since then. Since October 2000, he is working as professor of Crop Science and Ecological Agriculture at the Martin-Luther-Universität in Halle/Wittenberg. Besides working on matters of sustainability, his research concentrates on the development and evaluation of arable production systems.

Dipl.-Ing. agr. Zita O'Halloran-Wietholtz added a master study of rural development at the University College Dublin, Ireland, to her studies of agriculture at the Christian-Albrechts-Universität in Kiel. Since her return to Germany, she is employed at the Zentrale Markt- und Preisberichtsstelle in Bonn.

The documentation:

The complete volume 3/2002 of the ilu-series deals with the possibilities to measure sustainable development in agriculture with the help of appropriate indicators. Besides the general function of indicators for a sustainable development, the authors present individual models and systems, an evaluation of the applicability and an analysis, whether threshold values can be used for single indicators. Also, the general problem of setting threshold values, the aggregation of indicators, and finally possibilities of and limits to their use are presented.

The Institute for Agriculture and Environment (ilu):

The Institute for Agriculture and Environment was founded under the roof of the Association for the Promotion of Integrated Farming (FIP) in Bonn in 1997. Together with experts from different disciplines of the agricultural and environmental sciences, the collection of data and facts, analyses, consultations and documentations are performed in project teams. The documentation presented here has been published as volume 3/2002 of the ilu-series.

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European Initiative for Sustainable Development in Agriculture (EISA)
Konstantinstraße 90,
53179 Bonn
Tel: 00 49 (0)2 28 – 9 79 93 0
Fax 00 49 (0)2 28 – 9 79 93 40
e-mail: ilu@fnl.de, internet: http://www.fnl.de/ilu/iluindex.html

authors: Prof. Dr. Olaf Christen, Institut für Acker- und Pflanzenbau, Martin-Luther-Universität Halle/ Wittenberg
Dipl.-Ing. agr. Zita O'Halloran-Wietholtz, Institut für Acker- und Pflanzenbau, Martin-Luther-Universität Halle/Wittenberg

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Contact information

EISA
Susanne Witsch
Konstantinstraße 90
D – 53179 Bonn
Germany
Tel: +49 (0)228 97 99 333
Fax: +49 (0)228 97 99 340
e-mail: s.witsch@fnl.de

For further information, please contact:

Jean-Marie Mutschler
FARRE
113, avenue Jean-Baptiste Clément
f- 92100 Boulogne Bilancourt
France
Tel: +33 (0)1 46 05 07 14
Fax: +33 (0)1 41 10 84 77
e-mail: farre@farre.org

Dr Jürgen Fröhling
FNL e.V.
Konstantinstraße 90
D – 53179 Bonn
Germany
Tel: +49 (0)228 97 99 30
Fax: +49 (0)228 97 99 340
e-mail: info@fnl.de

Caroline Drummond
LEAF
National Agricultural Centre
Stoneleigh, Warwickshire CV8 2LZ
UK
Tel: +44 (0)24 76 41 39 11
Fax: +44 (0)24 76 41 36 36
e-mail: leaf@farmline.com

Gerard Conter
FILL
Service d'Economie Rurale
115, rue de Hollerich
L-1741 Luxembourg
Luxembourg
Tel: +352 478 25 76
Fax: +352 49 16 19
e-mail: gerard.conter@ser.etat.lu

Dr Roberto Gaidano
L'agricoltura che vogliamo
Viale Isonzo, 27
Italy
Tel: +39 02 58 30 26 15
Fax: +39 02 58 30 08 81
e-mail: rgaidano@trafficline.net

Lars Törner
Odling I Balans
Ormastorp
S – 260 30 Vallakra
Sweden
Tel: +46 (0)42 32 10 05
Fax: +46 (0)42 32 10 05
e-mail: info@odlingibalans.com

EISA represents the following organisations:

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