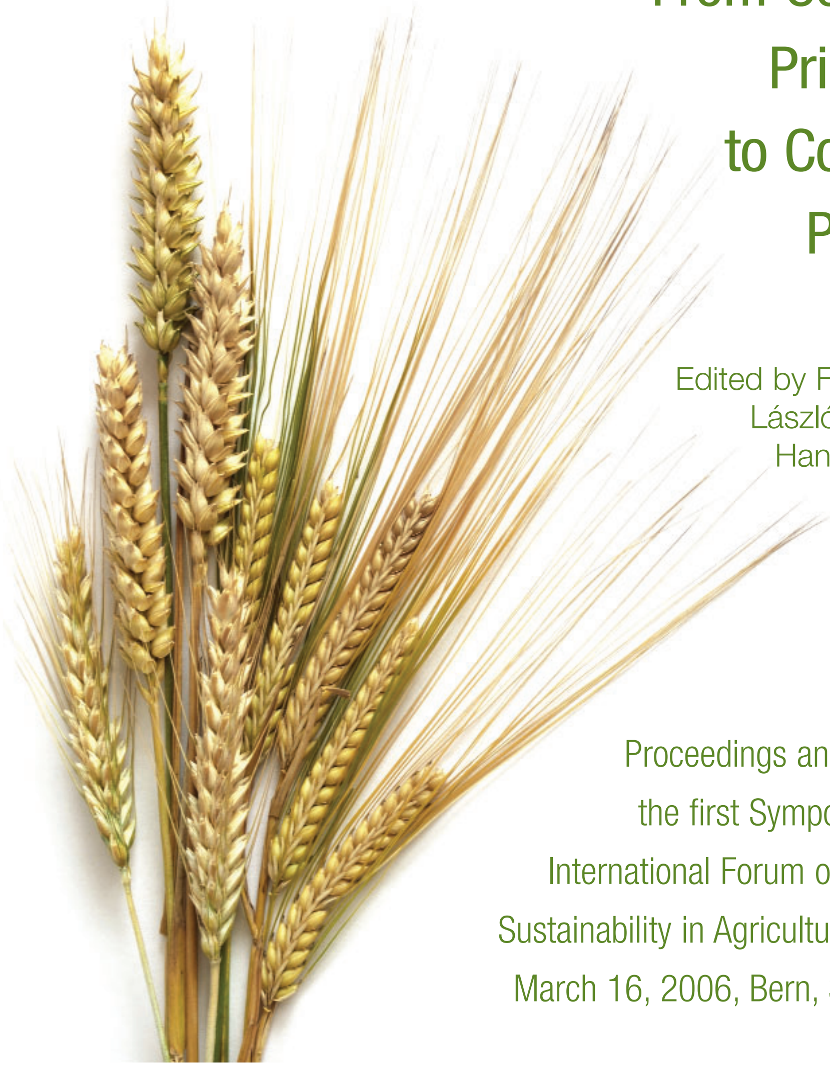
Sustainable Agriculture

From Common Principles to Common Practice



Edited by Fritz J. Häni, László Pintér and Hans R. Herren

Proceedings and outputs of the first Symposium of the International Forum on Assessing Sustainability in Agriculture (INFASA), March 16, 2006, Bern, Switzerland.

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A Dialogue on Sustainable Agriculture

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International Institute for Sustainable Development
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Bern University of Applied Sciences
Swiss College of Agriculture SHL

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International Institute for Sustainable Development
161 Portage Avenue East, 6th Floor
Winnipeg, Manitoba
Canada R3B 0Y4
Tel.: +1 (204) 958-7700
Fax: +1 (204) 958-7710
Web site: http://www.iisd.org

Swiss College of Agriculture
Länggasse 85
CH-3052 Zollikofen
Switzerland
Tel.: +41 (0)31 910 21 11
Fax: +41 (0)31 910 22 99
Web site: http://www.shl.bfh.ch

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The **Swiss College of Agriculture (SHL)** is the Swiss centre for agriculture, forestry and dairy technology within the Universities of Applied Sciences. Besides education it is active in applied research and development as well as providing services in Switzerland and abroad. The research focuses on holistic approaches to optimize agricultural production, to minimize negative ecological impacts of agriculture and to furnish practical recommendations for sustainable farming systems. SHL specializes in "on-farm research" and carries out interdisciplinary projects in which solutions of high practical relevance are developed in collaboration with the stakeholders. Project results and experiences are converted into practical recommendations and decision support tools that can be directly used by the stakeholders in agriculture, forestry and dairy technology.

The project group RISE (Response-Inducing Sustainability Evaluation), has developed a tool to assess the sustainability of farms and at the same time identify possibilities for improvement. The RISE-tool was tested and used for the public and private sector by evaluating different farm types on five continents and in 14 countries so far. The holistic sustainability assessment follows a systems approach and identifies strengths (potentials) and weaknesses with regard to sustainability. As a monitoring tool, RISE can visualize trends and developments over time on individual farms as well as within regions and samples.

The **International Institute for Sustainable Development** contributes to sustainable development by advancing policy recommendations on international trade and investment, economic policy, climate change, measurement and assessment, and natural resources management. Through the Internet, we report on international negotiations and share knowledge gained through collaborative projects with global partners, resulting in more rigorous research, capacity building in developing countries and better dialogue between North and South.

IISD's vision is better living for all—sustainably; its mission is to champion innovation, enabling societies to live sustainably. IISD is registered as a charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Government of Canada, provided through the Canadian International Development Agency (CIDA), the International Development Research Centre (IDRC) and Environment Canada; and from the Province of Manitoba. The institute receives project funding from numerous governments inside and outside Canada, United Nations agencies, foundations and the private sector.

Acknowledgments

The success of the first Symposium of INFASA and the proceedings was the result of the dedicated and tireless work of many colleagues at SHL, IISD and beyond, and the generous contribution of the presenters, participants and chapter authors.

The editors would like to highlight particularly the contribution of Carissa Wieler at IISD and Hans Porsche at SHL who helped throughout the process with project coordination and management, organization of the Symposium and arranging materials for the proceedings. The editorial process and publishing was guided by Stu Slayen at IISD.

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The Symposium took place at the Paul Klee Centre (ZPK) in Bern. The landscaping beautifully connects the urban area, architecture and agriculture.

Editors' Preface

Agriculture is faced worldwide with an accelerating transformation. Advances in science and technology, shifting consumption patterns, continuing population growth, trade globalization, frictions in subsidy regimes, and the impacts of local and global environmental change converge and lead to new and serious risks to agricultural production systems and producers.

In light of these changes, sustainability of the agri-food system and farming as a multi-functional enterprise is of increasing importance. Successful short- and long-term adaptation to endogenous and exogenous biotic and abiotic, social and economic forces requires access to information and indicators on the current situation and possible future trends in the ecological, social and economic domain of sustainability.

Although sustainability measurement and assessment has been on the research agenda of many organizations for quite some time, their actual impact on policies, practices and outcomes on the ground beyond pilot initiatives has been limited. Our hypothesis and strong belief is that if placed in the right context, and their value-added convincingly demonstrated, sustainability measurement and assessment has the potential to reduce long-term risk and advance the sustainability agenda well beyond the current state.

The Swiss College of Agriculture (SHL) and the International Institute for Sustainable Development (IISD) have launched a Forum (INFASA) to address the development and more strategic and widespread use of appropriate tools for a holistic sustainability assessment from the farm to higher organizational levels. The pillars of science, policy, corporate concepts and practice form the basis of a dialogue on these tools to strategically advance the agricultural sustainability agenda by linking technical and strategic aspects. Important elements in this dialogue are initiatives committed to promoting sustainable agriculture and its broad implementation, like the multi-stakeholder Roundtables (e.g., the Roundtable on Sustainable Palm Oil or the Common Code for the Coffee Community), the Sustainable Agriculture Initiative of the food industry (SAI Platform) as well as initiatives focusing on single environmental, social or fair trade aspects.

INFASA's primary objective is to communicate the value of different assessment tools to potential users. INFASA thus strives to promote the application of assessment systems in the field, advancing sustainable agricultural production from broadly accepted principles to common practices.

The first INFASA Symposium at the Zentrum Paul Klee in Bern from March 16–17, 2006, was a first step in a longer-term process to both advance methodologies and to build potential and capacity for their scaled-up use in decision-making. Bringing together developers and potential users of such tools shall raise the awareness of user needs, preferences and perceptions. These perspectives can be considered and integrated into future research programs and eventually lead to improved tools and broader application.

This book is the outcome of the first INFASA Symposium. It presents the state of the art in agricultural sustainability assessment. It also includes basic information regarding agricultural sustainability in a holistic context, the presentation of different tools, key papers, case studies and the results and syntheses of panel and group discussions, as well as the planned future activities of INFASA.

– Fritz J. Häni, László Pintér and Hans R. Herren

What's on the Enclosed CD-Rom?

Find out more about INFASA's inception and purpose in a pre-Symposium briefing paper, as well as Symposium activities, presentations and syntheses with the enclosed CD-Rom. Access the sights and sounds of the Zentrum Paul Klee in Bern, Switzerland, including the recording of a portion of a concert with an original composition written for INFASA and premiered at the concert. Resources also include a listing of presenters and participants and a compilation of proceeding abstracts.

A. About this CD (PDF 72 kb)

B. INFASA Proceedings, *Sustainable Agriculture: From Common Principles to Common Practice*, 2007 (PDF 4.5 mb)

C. INFASA Briefing Paper, *From Common Principles to Common Practice*, 2006 (PDF 664 kb)

D. INFASA 1st Symposium Program (PDF 1.17 mb)

E. Symposium Report (PDF 160 kb)
   1) Background and Overview
   2) What is INFASA?
   3) Keynote Addresses by Hans R. Herren and Wilfrid Legg
   4) Presentations and Posters, March 16, 2006, Zentrum Paul Klee
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      Appendix A: Acronyms
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Christoph Studer (PDF 2.58 mb)

David Pendlington (PDF 344 kb)

Eduardo Sampaio (PDF 228 kb)

Frédéric Zahm (PDF 584 kb)

Fritz J. Häni (PDF 1.91 mb)

Greg Strain (PDF 340 kb)

Hans Herren (PDF 19.2 mb)

Hans Jöhr (PDF 160 kb)

Kathy Lewis and John Tzilivakis (PDF 836 kb)

Vinzenz Jung (PDF 192 kb)

Wilfrid Legg (PDF 80 kb)

H. Abstract Compilation (PDF 58 kb)

I. Concert at Zentrum Paul Klee

1) In Retrospect – Review of Concert (PDF 1.65 mb)

2) Symposium and Concert Compilation Video (WMV 17.3 mb)

J. Photo Gallery (PDF 18.2 mb)

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Section 1

INFASA: International Forum on Assessing Sustainability in Agriculture

"From common principles to common practice"

Global Agriculture in Need of Sustainability Assessment

Fritz J. Häni[1]

F. HÄNI – Plant Protection and Agroecology, Swiss College of Agriculture (SHL), Bern University of Applied Sciences, Länggasse 85, CH-3052 Zollikofen.

1 The author wishes to thank Hans Porsche and Sonia Rodrigues (Swiss College of Agriculture) for their support and helpful suggestions.

Abstract

The demand for multi-functional merits from agriculture grows alongside the need to feed a growing global population. At the same time, the expansion of agricultural land and the intensification of production methods reach their ecological, economic and social limitations. Sustainable production, with its holistic principles, holds the key to finding an answer to these challenges.

In a world of globalized agriculture, sustainability should be measurable across regions, countries and commodities. For a fair comparison of different farm types and regions around the world, all strengths and potentials, as well as deficiencies and bottlenecks, must be considered. It is crucial that agricultural performance is evaluated according to the holistic principles of sustainable production. This means all three dimensions of sustainable development—ecology, economy and social aspects—are assessed and can compete for prominence. If only economic aspects are evaluated, this can lead to distorted decision-making, which in turn, can lead to social and ecological dumping.

The primary objective of the newly founded International Forum on Assessing Sustainability in Agriculture (INFASA) is to communicate the value of different indicator and assessment systems to potential users and to promote their use. INFASA strives for the application of indicator and assessment systems in the field, in order to advance sustainable agricultural production from a broadly accepted principle to a common practice.

Keywords: Trends in agriculture, sustainability indicators, standardized sustainability, holistic farm management, value added, early warning, globalization, ecological dumping, social dumping, agriculture and culture.

Looking at agriculture from the global as well as from a regional perspective—in the South and in the North—we can see a sector with great potential, but also one under great pressure due to multiple, rapidly unfolding interacting forces (Table 1).

Table 1: Growing pressures by 2030.

• Global climate change (energy requirements)
• Loss of fertile land (erosion, salinization, etc.)
• Pollution and biodiversity loss
• 1.5 billion more people, 1.5 billion undernourished
• 2.5 billions living in water-stressed or water-scarce conditions
• 50 per cent increase in demand for cereals and tubers
• Doubling of demand for livestock in developing countries

Sources: World Bank, CABI, FPRI, Rockefeller Foundation, IUCN, World Watch Institute (Vital Signs 2005, State of the World 2006), Meadows D. H. et al. *2004.*

In the upcoming 25 to 50 years, rural areas will need to supply two to three billion more people than today with food (World Bank, 2003). Providing this growing population with food will be the predominant role of farmers. However, as natural resources become scarcer, additional contributions of agriculture to society become recognized as merits. So far, the growing demand for food has largely been satisfied by agriculture through intensifying production systems and expanding the areas under cultivation. But this in a sense positive development has also caused negative effects. Overgrazing and inappropriate cropping have caused soil fertility to decrease in many places; large areas under agricultural production have been completely lost due to soil degradation. The expansion of agricultural land has increasingly come up against ecological limits. Consequences of current production methods include a loss of biodiversity, overexploitation of natural resources and contamination of soil, water and air, as well as other devastating environmental impacts (e.g., Troeh, Hobbs and Donahue, 1980; Heywood, 1995; Steiner, 1996; IAEA, 1997; World Bank, 2005).

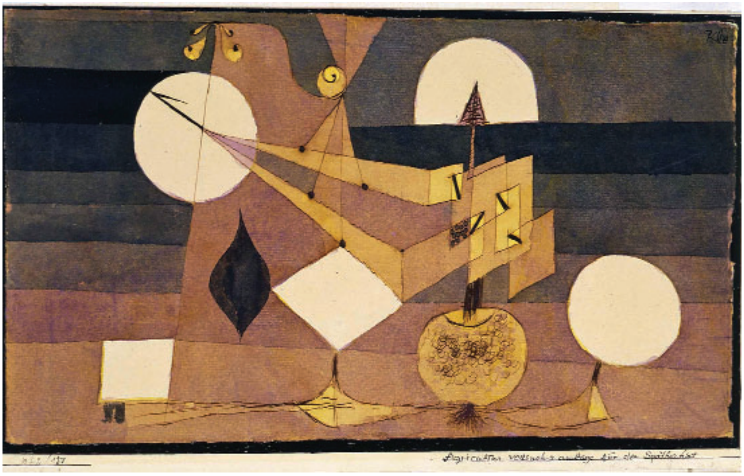
To find a framework for dialogue and action upon these issues two hypotheses might be helpful (cf., Kesselring, 2003; Ruh and Gröbly, 2006; Stückelberger, 1999):

Hypothesis 1: Today the greatest pressure on agriculture is due to the globalization of markets.

Hypothesis 2: Sustainable production is the most important leading principle to solve the predominant problems of agriculture worldwide.

Globalization and liberalization of markets are in fact exerting great pressure upon the economical, ecological and social performance of agricultural production. Mostly decreasing and highly volatile commodity prices have rendered many farms and even entire sectors unprofitable (Worldwatch Institute, 2003). The financial pressure on salaries and the expected return on investment (World Bank, 2003) may lead to ecological and especially social dumping, resulting in discrimination, child labour, forced labour and failure to provide the basic necessities like potable water, hygiene or protection from hazardous substances.

Figure 1: Agricultural research station for late autumn.



Paul Klee, Agricultural research station for late autumn, 1922, 137, pen and watercolour on paper on cardboard, 18.6 x 30.1 cm, Colby College Museum of Art, Waterville. Donation Jere Abbott.

These manifold pressures and unsolved problems highlight that it is time to act. Nevertheless, promising approaches need creativity. The International Forum on Assessing Sustainability in Agriculture (INFASA) and its first Symposium were launched in Bern, Switzerland, at the Zentrum Paul Klee. The stunning cultural centre and Paul Klee's paintings were intended to inspire participants. In this context it may also be interesting to note that the word *culture* has its roots in the word agri-*culture* and there is no doubt that a holistic reflection on farming still incorporates important cultural aspects.

As Figure 1 may illustrate, agricultural research is certainly needed. The fact that in the painting it is "late autumn" may remind us that it is also high time for a practical and broad application of available knowledge. In the context of growing social, economic and ecological problems it becomes clear that only a responsible agricultural production, which makes wise use of all its resources, can meet the exigencies put forward by traders, processors and consumers. The demand for sustainable primary production is increasing as food safety and internal product quality are supplemented by the urge for ecological, ethical and socio-economic quality aspects (Boller *et al*., 2004). Sustainable production therefore epitomizes a holistic view of quality aspects; whereas not only the quality of the product but also of the production system is included. In its last consequence, the holistic approach must cover the entire supply chain. Thus, sustainability in all dimensions has become a most important guiding value for agricultural production.

Although currently fashionable and often abused, "sustainable development" and "sustainable agriculture" are not outworn or dusty notions. They have evolved over the last 20 years (cf., Edens, Friedgen and Battenfield, 1985; Meadows *et al*., 2004), growing in importance relative to the political agenda at the international and national levels, with particular emphasis on ecological concerns.

While the principle of sustainable agriculture is broadly accepted, the systematic consideration in practical farm management is still very limited (Pintér and Häni, 2006). One major reason for this may lay in the frequent assumption that sustainability is merely an ecological concept. The result is a kind of "greenish" impression that marginalizes economic and social aspects. Not only are they at least as important as ecological aspects, but also the public awareness for them seems to be growing.

Before assessment tools are developed it is, therefore, necessary to define sustainability. A well accepted and probably the most broadly used one for sustainable development is the definition of the Brundtland Commission (WCED, 1987). At the Swiss College of Agriculture we found it to be a very good basis for our work (Häni *et al*., 2002, 2003a, b, c). Nevertheless, it has turned out that some key aspects are missing (they may have been included implicitly, but to become operational they have to be explicit). Three further dimensions were, therefore, added to the original definition (Stückelberger, 1999, modified): "human dignity," the (local) "natural environment" and the "global ecosystem."

Therefore, a basic definition of sustainable development can read as follows (Häni *et al*., 2002, 2003a):

> *Sustainable Development allows a life in dignity for the present without compromising a life in dignity for future generations or threatening the natural environment and endangering the global ecosystem*.

Transcribed for practical use in agriculture and to make it operational for assessment tools, the definition for sustainable agriculture reads (SAI, 2003, modified):

> *Sustainable agriculture adopts productive, competitive and efficient practices, while protecting and improving the environment and the global ecosystem, as well as the socio-economic conditions of local communities in line with human dignity*.

Although numerous methods to evaluate sustainability on a global, national and local level (e.g., UN, 2001; OECD, 1997, 1999) and various environmental licensing and labeling options (ISO 14040, EurepGAP, Organic, etc.) are available, holistic management tools at farm level are still very rare. Most of the existing methods cover only single, specific quality aspects. Nevertheless, many of them are expensive and complex, often an exclusion criterion for small farmers. Furthermore, most audits communicate requirements rather than provide constructive criticism and intervention points for improvement. In addition, there has been little success so far in communicating to consumers the achievements as well as problems that agricultural production faces with regard to sustainability.

The International Forum on Assessing Sustainability in Agriculture (INFASA) is consequently focused on holistic assessment tools for practical use and risk management at the farm level but also looks at their usefulness for aggregation and political impact. The case studies presented during the first INFASA Symposium and published in this book explore the application of such management tools.

Holistic assessments provide farmers and other stakeholders with insight into ecological, social and economic aspects of farming and play a key role in advancing sustainability. It is important to begin analysis at the farm level, but in a way that allows information to be aggregated at various levels, including groups of farms, or the regional, national or international level.

It is crucial that the farmer himself can see an added value and can benefit from an assessment. He is still the central, most important actor, at least at the farm level. Nevertheless, he tends to be neglected because subsequent sectors in the supply chain often provide more financial added value. Only the farmer can manage and harvest the enormous, natural potential of regenerating raw material (renewable resources) without having to deplete non-renewable resources. The social and economic situation of the farmer is, therefore, a key factor for a sustainable society. Efforts should certainly be made to prevent farmers and the people working on and around farms from being "made fools" of or treated like puppets (Figure 2).

Figure 2: The peasant from the puppet-show.

Paul Klee, The peasant from the puppet-show, 1939, 1200, chalk on paper on cardboard, 29.5 x 20.7 cm, Zentrum Paul Klee, Bern. Donation Livia Klee.

Sustainability assessment tools will obviously not prevent the current "extinction of farmers" in many countries—in Switzerland about 1,600 farms close every year (from a total of 65,000 Swiss farms), of which about 1,000 are full-time farmers (from a total of 45,000). Assessment tools can not protect farmers from being "struck from the list" (Figure 3),[2] but they will provide access to information through indicators on the current situation (state) and possible future trends (driving force) and will act, therefore, as early warning systems.

Figure 3: Struck from the list.

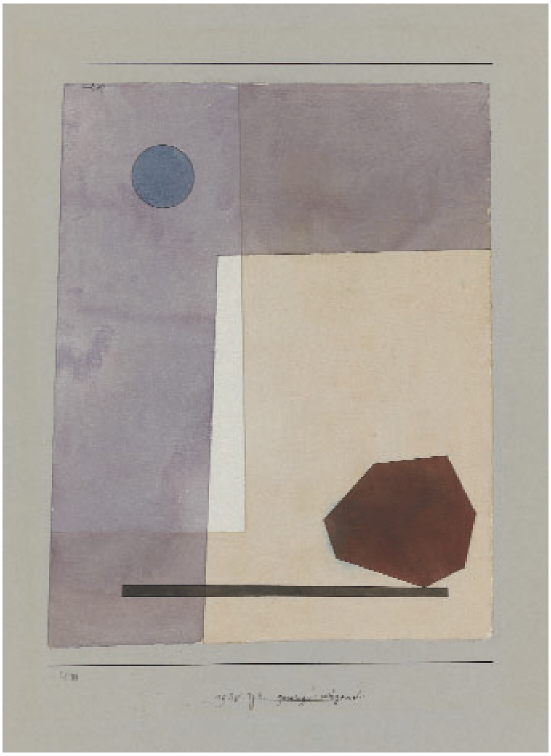
Paul Klee, Struck from the list, 1933, 424, oil on paper on cardboard, 31, 5 x 24 cm, Zentrum Paul Klee, Bern. Donation Livia Klee.

"Do we really dare to measure, to balance?" (Figure 4). Yes, that is the very reason for which INFASA was founded and why its first Symposium on indicator and assessment systems was organized. But the discussions before, during and after the Symposium have further raised the

2 The original intention of this painting (Figure 3) was obviously different. It appears to have been an allusion to Klee's dismissal without notice as a professor in Düsseldorf (his work being considered as "degenerate art") when Hitler became Reich Chancellor in 1933.

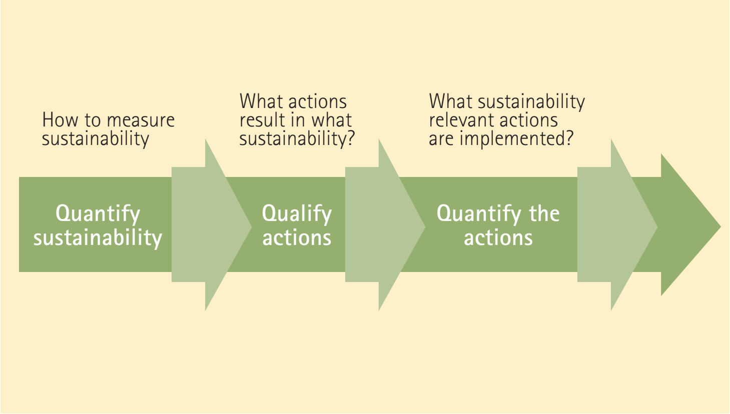
awareness that the ambiguity in the title of Klee's painting has its profound justification. To quantify precisely such a complex system like a farm has its limits and may not even be an important objective. When it comes to measuring things like the value of biodiversity, we simply have to conclude that this is, in fact, impossible. But even for aspects like biodiversity, where the available knowledge is still rather limited, there are lots of specific actions that can be assumed as favourable (Boller, Häni and Poehling, 2004; Häni, Boller and Keller, 1998). What, therefore, is essential is the evaluation of actions that may be considered relevant for sustainability (Figure 5). Where only an approximation of the relevance of these actions is possible at present, it may be regarded as a necessary first step to get an idea of the whole picture and not to fall into the pitfall of only taking into account what is easy to measure.

Figure 4: Daringly balanced.



Paul Klee, Daringly balanced, 1930, 144, watercolour and pen on paper on cardboard, 31 x 24.5/23.5 cm, Zentrum Paul Klee, Bern.

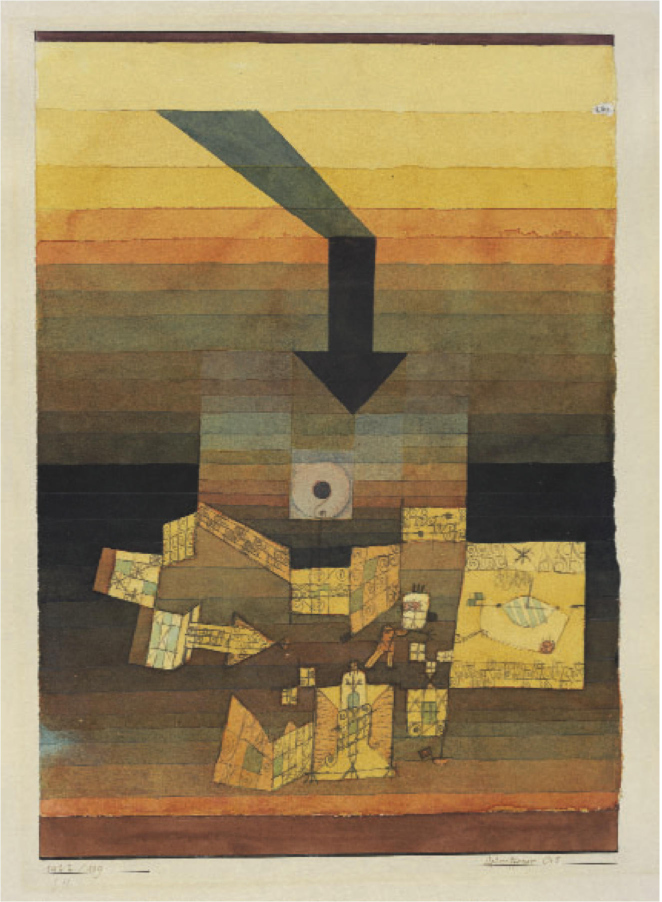
Figure 5: Even where more scientific work is required to quantify sustainability (left), the evaluation of actions with a probable sustainability impact (right) is important to developing more comprehensive management information.



Unfortunately, today the cost of production is often used as the only relevant indicator for decision-making, ignoring the framework conditions. This is fundamentally wrong, because it only takes part of a farm's achievement into account. In a holistic assessment, it is crucial that the entire performance, including multi-functional merits, are evaluated and put into context. Only if this is done, benchmarking and competition in all three dimensions (ecology, economy and social aspects) is possible.

Preferably the methods used should be standardized in order to allow comparability while still being applicable around the world. The whole world is the "affected place" (Figure 6). In a globalized agriculture the sustainability should be measurable across regions, countries and commodities. In a fair comparison, advantages and disadvantages, and potentials and bottlenecks of different farm types and regions around the world should be visualized. The methodology has to be reasonably complete, robust and scientifically accurate but still easy to implement. "It has to be as simple as possible but not any simpler," as Einstein stated. In order to have a broad impact, i.e., to be widely applicable, it must also be relatively inexpensive. The required tool has to serve the farmer and other entities and to know the strengths (potential) and possible deficiencies of the production, thereby, allowing for improvement.

Figure 6: Affected place.



Paul Klee, Affected place, 1922, 109, 30.7 x 23.1 cm, Zentrum Paul Klee, Bern.

It is the intention of the International Forum on Assessing Sustainability in Agriculture (INFASA), to address the broad, worldwide use of indicator and assessment systems for sustainable agriculture. The pillars of science, policy and practice will form the basis of an ongoing dialogue on these tools to strategically advance the agricultural sustainability agenda by linking technical and policy aspects.

The primary objective of INFASA is to communicate the value of different indicator and assessment systems to potential users and to promote their use. To this end, INFASA aims to develop an intensive exchange of experiences—among scientists and developers as well as users—in order to improve and adapt the tools. INFASA thus strives for the application of indicator and assessment systems in the field, in order to advance sustainable agricultural production *from a broadly accepted principle to a common practice*.

INFASA is an open platform, welcoming the participation of all stakeholders (farmers, the agri-food and supply industry, retailers, governmental bodies, consumers, NGOs). Furthermore, INFASA will provide a forum where concrete applied research programs can be conceptualized in response to the needs of specific audiences. We are quite aware that *working together* with such different interest groups may be more complicated than individual initiatives. But the goal is not necessarily unanimity. Einstein stated, that "the day where all participants express the same opinion, is a lost day." Therefore we are most thankful that the first Symposium of INFASA in Bern, where Einstein had his *annus mirabilis*,[3] wasn't a lost day. What is indeed needed for a more sustainable agriculture are new alliances, cooperation and joint strategies, in particular in industrialized countries, where farmers—just like cultural institutions—are often heavily dependent on the goodwill of fellow citizens.

It is much more than a simple coincidence that the first INFASA Symposium took place at the Zentrum Paul Klee in Bern (ZPK), a site of cultural interest to which the Swiss College of Agriculture has both an intensive relationship and interest in terms of intertwining with the former's societal mandates. The concert given at the ZPK during the Symposium connected classical and modern music with topics of art and nature in order to reflect the fact that sustainable agriculture has a much older history than the sole existence of the term might imply. The music that included pieces composed specifically for this event was not only part of an added "cultural program," but also thought of as an integral part of the Symposium and an inspiration for all participants. Hopefully, the few selected paintings of Paul Klee in this paper (at the Zentrum Paul Klee some 4,000 more are waiting to be discovered) will be a rich source of inspiration for the scientific and practical work of the readers.

3 Einstein had his *marvellous year* in 1905 (e.g., "Special Theory of Relativity" and paper on light quantum theory for which he earned a Nobel prize in 1921).

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A Strategic Approach to Influencing Agricultural Policy and Practice through Measurement

László Pintér,

L. PINTÉR – Measurement and Assessment,
International Institute for Sustainable
Development, 161 Portage Avenue East, 6th floor,
Winnipeg, MB, R3B 0Y4, Canada.

Agriculture is one of the most ancient forms of art and science that ties human development and well-being to natural resources and ecosystems. Although trade in agricultural commodities can create an illusion of the separation between farmer and consumer, the two are in fact always tied together. In today's characteristic mass market and long value chains, the links and interdependencies between producer and consumer are not immediately visible, or become visible only if supply and demand is out of sync.

As all farmers know, being in the business of farming is inherently risky. Risk comes in the form of a myriad of factors, from pests and weather to changes in market conditions and government policies. Although sustainability has been defined in many ways, it can be thought of as an ability to manage risk without compromising human and ecosystem well-being over time. Managing risk is an ongoing enterprise and it requires constant learning and adaptation. It involves, among other things, regular monitoring of crop status and reserves, and market demands for commodities and specialty products. However, it also involves monitoring key aspects of agriculture's environmental framework conditions, and understanding the social resilience and economic viability of farmers, farming communities and agricultural enterprises.

While agriculture is always risky, there are indications that the sector is entering a more turbulent phase of increased risk and uncertainty. Amidst a mix of signals and interpretations, there appears to be warnings that profound change is needed to maintain or restore stability of the world food system.[1, 2]

Among forces of change, the policy issue that receives the most media attention is trade liberalization and the question of agricultural subsidies. Changes in trade and subsidy regimes no doubt have major worldwide repercussions. However, sustainability concerns of the sector run much deeper. Some of these such as demographic change or consumption habits are set to virtually guarantee that the demand for agricultural commodities and more highly processed food will continue to grow. Increasing affluence in countries such as India and China, partnered with an increasing demand for commodity-based biofuels, is expected to raise prices for dual-use food crops and lead to the more widespread use of monoculture. Others on the supply side point to increasing stress

1 Braun, J. von, 2005, *The World Food Situation: An Overview*. Washington DC: IFPRI. Available at: http://www.ipsnews.net/news.asp?idnews=33268.

2 Leahy, S., 2006, *Global Food Supply Near the Breaking Point*. Available at: http://www.ifpri.org/pubs/agm05/jvbagm2005.asp.

related to climate change, water resources, land quality, agricultural biodiversity and a range of other interacting problems.

While each of these trends has significant impacts on agri-sustainability in their own right, cumulative impacts are of greater concern. These are harder to foresee and avoid. Sustainable agriculture is not agriculture without risk, which would be unrealistic to expect. It is agriculture that is able to manage risk and maintain its resilience in the face of change and inevitable surprise. Farmers are traditionally resourceful and resilient, but the sustainability of the supply chain increasingly depends also on the ability of other actors to recognize and adapt to emerging challenges.

The connection between the increasing vulnerability and complexity of the sector and the vision of INFASA is surprisingly straightforward. Managing risk and navigating the path to sustainability requires strong evidence that can be used for credible diagnosis and effective adaptation. Being able to anticipate and diagnose risk and potential for unsustainability requires measurement tools, processes and institutions that create and use credible tools well.

As evidenced by those participating in the INFASA Symposium, technological innovation and an increasing focus on agri-sustainability indicators is growing in the research and policy community. There is, however, significantly more we can do. We can begin by widening our audience to the unconverted. We can also work together to shift the focus of measurement tools from research and pilot projects towards more widespread and systematic implementation.

The underlying premise of INFASA is that current measurement tools, processes and institutions involved in assessing sustainability in agriculture are often not well suited to the task. Market prices, for instance, often do not capture long term environmental risk, nor to they include mounting social stressors, fiscal or otherwise, on farm families. Data availability for key indicators are often poor or don't cover all areas of the world, particularly developing countries. We don't know how to affectively combine data from science-based monitoring and farmer or indigenous observations, the latter of which are based on generations-old knowledge of the land. Because these factors matter for agricultural sustainability, we need to more widely introduce the measurement tools and mechanisms for which there are already many examples. I think the farming community is ready for this, as are many in agri-business and government.

INFASA may also have the potential to help us move beyond the status quo by clarifying the role of measurement tools in policy processes and strategies. Over the last 15 years, the expert community has made great efforts to build and improve measurement tools, and to develop and publish indicator reports and analyses. While probably useful in their own right, indicators are most useful when they are tied to strategic policy cycles and the performance expectations of key actors. We cannot assume that general arguments about the need to improve measurement systems and tools will alone advance the agri-sustainability agenda. No matter how advanced measurement tools are, they are only a means to an end, and without a clear link to information needs, policies and performance requirements, they will have limited impact.

The good news is that there is no shortage of policy issues that currently or will require a significantly improved evidence base. For example:

- Standards: As the emphasis on standards and certification schemes is increasing, the need to monitor adherence to these schemes, their impact and potential advantages will also grow.
- Value chain analysis: Due to longer value chains, the impact of agricultural production is often spread around the globe. From the point of view of trade, countries will want to know that some exporters are not enjoying an unfair advantage by simply externalizing costs (e.g., the environmental costs of production). This cannot be done without regular monitoring and preferably quantitative evaluation.
- Food security: As food demand grows faster than supply (at best), analysis and early warning of potential crises will become increasingly important.
- Full cost pricing and natural capital: The notion of natural capital accounting has gained prominence. However, the calculation of natural capital requires underlying physical data, such as hectares of land, soil quality or quantity of groundwater. Indicators are the basis for these calculations.
- Sustainability reporting and strategies: Where these are being implemented, indicators are a must to help identify targets and report on progress.
- Budget processes: Measurement helps inform the budget process and establish priorities that minimize risk and facilitate adaptation.
- Impact assessment: To understand the impact of new technologies or changes in production systems, indicators are needed at regulatory and farm levels, where decisions about technology adoption take place.

As the above examples indicate, the need and potential for making use of systematic and holistic measurement systems is broad. In fact, many comparable if not identical initiatives have emerged over the last decade or so with a focus on indicator systems that reflect priorities of sustainable agriculture. This growing interest in measurement and assessment almost inevitably leads to increases in the diversity of tools and approaches, and a need for building bridges and synergies, as illustrated by the Bellagio Principles, or more recently the OECD's Istanbul Declaration.[3, 4] While diversity is necessary and useful, it can also hinder building synergies. Communication across the practitioner community is particularly important for building momentum towards joint policy agendas. Without this, the impact of sustainability measurement would be fractured and limited.

INFASA represents an opportunity to bring together the expert and policy communities from both the public and private sector, North and South, to discuss and influence or inform the research and policy agenda on measuring and making the best use of measures of sustainability from both the socio-economic and environmental point of view. The Symposium is about mutual learning and dialogue. It is also about crafting a research and possibly, a policy agenda. Its goal should be to move indicators beyond the research phase and into the wider practice of the producer, agri-business and policy community where positive impacts for both human and ecosystem well-being in the future can be realized.

3 http://www.iisd.org/pdf/bellagio.pdf.

4 http://www.oecd.org/LongAbstract/0,3425,en_2649_34487_38883775_119829_1_1_1,00.html.

Headlines from the 1st INFASA Symposium in Bern, Switzerland, March 26-27, 2006

The INFASA Symposium provided an overview on indicator models and assessment tools of agricultural sustainability (cf., Section 2, attached CD and IISD homepage on assessment tools). It also identified expectations, needs and potential application areas of different stakeholders. A further goal was to provide opportunities for improved collaboration and coordination.

The discussion showed that working together (being a basic objective of INFASA) is a challenge for industry, policy-makers, science and farmers for the following reasons:

1. The different stakeholders have partially different priorities:
   - consumer confidence, bottom line (industry);
   - justification for special support of agriculture, public health (policy);
   - better understanding of systems, decision support tools (science); and
   - added value for farmers.
2. There exist different expectations on detail and accuracy:
   - complex, scientifically-credible systems vs. easily communicated, simple and cheap tools; and
   - standardization and comparability vs. site/stakeholder-oriented approaches.

The following statements summarize some of the main results of the Symposium:

- *Common language* and terminology, common goals and harmonizing concepts still need to be further developed.
- *Clear definition* of sustainable agriculture, including the key element of relevant, sustainability criteria.
- *Goals* should be known before starting in order to develop assessment tools and indicators. What do we want to measure and why?
- *Holistic approach* with balanced consideration of the social, economic and ecological dimensions is important for preventing one-sidedness.
- *Social dimension* is often neglected because it is difficult to measure. The methodology needs to be improved.
- *Values* of all stakeholders need to be taken into account to maintain a holistic approach.
- *Participation* is essential for indicator development and/or interpretation of results as it helps increase ownership, buy-in and relevance to users.
- *Standardized tools* are important for international comparison, with the qualification that unique regional conditions should also be taken into account.
- *Systemic perspectives* show that social, economic and ecological conditions may differ at each level of the food supply chain and across geographic scales (global, national, regional and farm level).
- *Linkage to policy* issues and agendas, primarily sector strategies and clearly defined standards and certification helps to ensure impacts on agricultural practice.
- *Varying complexity* is needed for different target users. Indicators will be more broadly defined at the global level, and more diversified with different emphases at local levels.
- *Tradeoff between complexity and manageability* is needed for simple, robust systems that users can understand ("As simple as possible, but not simpler," Einstein).
- *Quality constraints* for assessment tools, methods and processes are fundamental.

- *Data availability* continues to be a major challenge. Indicators developed in interaction with agencies in charge of statistical accounts, certification or extension can help address these challenges.
- *Communication with indicators*, both visually and otherwise, needs to be mindful of the information needs and capacities of multiple audiences.
- *Capacity building* at the farm level is needed to make the best use of indicator systems and to provide an added value to farmers.

Section 2:

Tools for Assessing Sustainability in Agriculture

Introduction

Tools for a holistic assessment of what are typically identified as the three main dimensions of sustainability (ecology, economy and social aspects) at the farm level have emerged as a result of the need to systematically evaluate agricultural sustainability in ways that are appealing, relevant and understandable for farmers, policy-makers and consumers alike. As is highlighted by the papers included in this section, assessment tools are increasingly developed for multiple purposes and to address cross-scale issues with a combination of sophistication and pragmatism.

The need for systemic assessment approaches that "integrate the multi-functionality of agriculture" is emphasized in Binder, *et al.*'s work. Such an assessment should enable the selection of indicators that can be used across scales. Binder *et al*. focus on trans-disciplinary processes that include an integrative model, the determination of goals through consensus, analysis of inter-linkages among indicators and definition of normative ranges of sustainability. Further, it is highlighted that better linkages across scales and between the ecological, social and economic dimensions are required, as Binder *et al*., Häni *et al*. and Ochola *et al*. note.

Beyond monitoring the current sustainability of agricultural practices, Zahm *et al*. use assessment tools to perform a diagnosis; Häni *et al*., Ochola *et al*., Pervanchon and Zahm *et al.* provide a focal point for dialogue; Häni *et al*. and Zahm *et al*. detect points of intervention, Häni *et al*. and Ochola *et al.* monitor policy objectives and agricultural extension; Zahm *et al.* provide comparisons among farm types or production practices; and Ochola *et al*. help scope out the range of impacts of future activities.

Tools presented here range from purely qualitative approaches intended to initiate thinking about sustainability practices among farmers, such as Trame (Pervanchon, this volume), to primarily quantitative approaches based on models that are diagnostic or predictive in nature (i.e., RISE, IDEA). Visual presentation of complex information in a snapshot that is intuitive and easy to grasp is important. Pervanchon's Sustainability Farm Tree, Häni *et al.*'s spider diagram of RISE, Ochola *et al.*'s spatial mapping or Zahm *et al.*'s graphical analysis of the IDEA method illustrate options rendering assessment results comprehensible for various stakeholders. An underlying purpose of the tools presented here is to provoke dialogue and participation among stakeholders whether by engagement in the collection of data, active interpretation of trends and dynamics, or direct implementation of responses (e.g., RISE). As Ochola's paper demonstrates, the construction and active use of indicators in making practical farm-level decisions has direct applicability not only in developed, but also in developing countries.

Given our global economy, standardized tools and methods that can assist with the selection of production types and locations by identifying advantages and disadvantages, are inherently necessary. At the same time, certain regional conditions, such as culture, may not be amenable to standardized approaches. Tools like RISE, the IDEA method and analyzes based on disaggregated indicator sets have both universal applicability, as well as suitability for locally adapted customization and interpretation. Regionally adapted management practices are possible with the involvement of local extension services.

The Role of Transdisciplinary Processes in Sustainability Assessment of Agricultural Systems

Claudia R. Binder and Arnim Wiek[1]

C. R. BINDER – Social and Industrial Ecology, Department of Geography, University of Zurich, Winterthurerstr. 190, 8057 Zurich, Switzerland.

A. WIEK – Institute for Human-Environment Systems, Natural and Social Science Interface, ETH Zurich, Universitätstrasse 22, CHN K 73.1, 8092 Zurich, Switzerland.

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Abstract

This paper first analyzes potential shortcomings of current sustainability assessment approaches as found in literature. These shortcomings relate to: (i) integrating the multi-functionality of agriculture; (ii) selection of and linkages among the indicators at different scales; (iii) assessing sustainability from an integrated perspective; and (iv) the application of the obtained results. To overcome some of these problems we suggest developing a Sustainability Solution Space (SSP) in a transdisciplinary process. The SSP process consists of a prerequisite phase, a systemic module, a normative module and an integrative module. At each step, a transdisciplinary process can be envisioned. In the prerequisite phase, the goals for the case to be assessed are defined in a consensus-building process. The systemic module provides a sufficient system description by selecting indicators and analyzing inter-linkages among the indicators. The normative module aims at defining sustainability ranges for each of the selected indicators and thus, incorporates scientific judgments, as well as values and preferences of stakeholders. Finally, the integrative module combines the systemic and normative aspects and provides a Sustainability Solution Space for the agricultural sector of a defined region. The transdisciplinary process ensures that the knowledge and values of the regional stakeholders are included. This is particular relevant for the selection and assessment of socio-economic indicators. These indicators might significantly vary in their assessment regarding sustainability across cultures, so that comparability and benchmarking might be restricted to culturally homogeneous groups. This indicates that also during the interpretation of the results and the development of improvement strategies, stakeholders ought to be involved. A transdisciplinary process, thus, is likely to improve the soundness of the sustainability assessment and to support the implementation of the elaborated strategies.

Keywords: Sustainability assessment, agricultural system, transdisciplinary processes.

1. Introduction

Sustainable agriculture is a widely discussed topic by researchers and practitioners. The definition of sustainable agriculture ranges from conservation and management choices (erosion prevention, integrated pest management, etc.) to national perspectives such as food security. Assessment methods include counting the implementation of good practice (Goldmann, 1995) to a systemic analysis of interdependencies. The goals for each of these views vary significantly and so do the indicators that can be used to measure the sustainability of agriculture or agricultural practices (see Smith and McDonald, 1998). In assessing the sustainability of the agricultural sector, the following problems are encountered:

Multi-functionality of agriculture. Agriculture has to fulfill multiple functions, such as, food security and landscape conservation. The main concern/main function of agriculture varies within continents, countries and regions. How can these goals be consolidated? Which functions and goals have priority? Panell and Schilizzi (1999) discuss competing objectives and the difficulty of measuring and assessing sustainability with respect to these goals. For example, it might be a goal to protect water bodies from pesticides and fertilizers, but at the same time, agricultural production has to be intensified to be able to supply the population with enough food.

Scales. The sustainability of agriculture can be assessed at different scales. Smith and McDonald (1998) identify four scales: field; farm; watershed; and regional/national scale. At each scale, different perspectives and goals of sustainability are dominant and different indicators are required for the assessment. In addition, the global scale could be used to assess the effect of trade on the sustainability of national food systems.

Selection of the appropriate indicators. The selection of indicators is also affected by the aspect of scale (Smith and McDonald, 1998). Additionally, cultural issues play an important role. For example, Seitlinger (2006) shows that even some of the parameters that allow for a sustainability assessment of agriculture at farm-level in different countries of different continents (Häni *et al.*, 2004; Häni *et al.*, 2005) are not necessarily adequate for doing so in the context of small-holders in Colombia, South America. Thus, one important issue is to differentiate between indicators that are not affected and those that might be affected by cultural conditions. The latter are likely to be related to social and economic aspects.

Linkages and integration of indicators. Some of the authors analyzing and providing tools for assessing the sustainability of agriculture talk about the insufficiency of indicators as assessment instruments. They claim that there is an explosion of indicator lists, in which no connection among the indicators exist and which therefore are difficult to interpret (Panell and Schilizzi, 1999; Smith and McDonald, 1998). Often these indicator lists have problems with regard to: (i) representing the system and its problems; (ii) including all of the three dimensions of sustainability (UBA, 1997); and (iii) considering interdependencies among the indicators.

Even though the need for integration of indicators is evident, there is no convincing approach as to how these indicators can be linked in order to provide an overall picture of how changes of an indicator in, for example, the social area, might affect the ecological area (Wiek and Binder, 2005). A first approach in this area is provided by Gustavson *et al*. (1999). They analyze the relationship among indicators using a correlation analysis. This analysis provides first insights of the interaction between indicators, and can help to reduce the number of indicators. However, the analysis is quite data intensive and no causal relationships should be derived from them. Another approach is provided by Häni *et al*. (2002; 2003). In the RISE assessment approach, each indicator is composed of several values leading to a state and a driving force parameter for each indicator. Changes in the underlying values might affect several parameters and, thus, several indicators. However, also in this approach, the relationship among the indicators is not explicitly considered.

Assessment of sustainability. Even when indicators are selected and measured, one question remains open. Is the agricultural system at the studied scale sustainable or not? Morse *et al*. (2001) discuss the assessment problem. The information relating to whether an indicator is above or below a certain value makes it very difficult to make policy decisions because another indicator, affected by the same policy, might point to the opposite direction. They consider the possibility that looking at indicators by themselves can provide an entry point to the sustainability discussion, but as soon as the values of the indicators have to be judged and linked to others, "objectivity" is lost, i.e., the assessment of sustainability has to include: (i) the inter-linkages of the indicators; and (ii) the normative criteria, i.e., sustainability criteria and/or national goals. In addition, the assessment of what is sustainable and what is not might vary across countries.

Application of the assessment results. Even though the obtained results would lead to a more sustainable agriculture at farm, regional or national level, these assessment tools have not yet been broadly applied.

One of the reasons might be that there is no consensus among researchers, policy-makers and farmers with respect to the selected indicators; no consensus on the point when they become sustainable; and no consensus on what indicators should be prioritized and thus, which strategies should be selected.

This paper shows how a transdisciplinary procedure can be applied to overcome some of the described problems. Hereby we rely on the methodology of Sustainability Solution Spaces (Binder and Wiek, 2001; Wiek and Binder, 2005) and on transdisciplinary methodologies ranging from participatory to collaborative and interactive social research (Scholz *et al*., 2006; Robinson and Tansey, 2006; Hirsch Hadorn *et al*., 2006; Rist *et al*., in press). We focus on the following of the aforementioned problem areas: (i) accounting for multi-functionality and multiple goals; (ii) selecting indicators; and (iii) defining what is sustainable, (analysis of the normative criteria). We also address the following questions:

1. How can multi-functional systems be represented and indicators derived?

2. How can the indicators and their sustainability ranges be defined?

3. Which indicators and their sustainability ranges are likely to vary across cultures?

2. Steps for constructing a Sustainability Solution Space (SSP)

We sketch the core components of the SSP procedure (Table 1) that is elaborated in detail in Wiek and Binder (2005). Preliminary to constructing an SSP, we have to consider the function the sustainability space has to fulfill (*prerequisite phase*). Who will use this tool and for which purposes? That is, we depart from the final product we want to obtain: e.g., an SSP for policy-makers in the area of agriculture. The transdisciplinary approach in this prerequisite phase allows for including and balancing the different views and objectives stakeholders might have.

The method itself consists of a systemic, a normative and an integrative module (Table 1). The modules are interdependent; constructing an SSP is thus not a linear procedure but an iterative process.

The *system module* is the basis for the Sustainability Solution Space. It: (i) describes and defines the system with its characteristics and its main problems; (ii) derives indicators (environmental, economic and social); and (iii) determines the relationship among the indicators (e.g., synergistic, antagonistic or neutral). Note that the system module is already constructed in a transdisciplinary process, i.e., with the participation of stakeholders.

The *normative module* sets the criteria for defining sustainability ranges. It departs also from a viewpoint of the agent (e.g., policy-maker) but includes the perspective of sustainability sciences. For each indicator, a sustainability range is defined, i.e., a minimum and maximum value is set according to the selected criteria. It has to be considered that the selected sustainability ranges depend on the preferences and values of the agents defining them.

The *integrative module*, finally, integrates the sustainability ranges defined in the normative module with the results obtained in the system module. A consistency analysis (cf., Tietje, 2005) analyses whether the selected sustainability ranges are in agreement with the defined indicator system. The result is the Sustainability Solution Space (SSP). It shows within which ranges the values of the indicators can vary without hampering the sustainability of the whole system. Or putting it in other words: in which areas, measures have to be taken in order to improve the sustainability of the system. The construction of a sustainability space consists of the six steps shown in Table 1, (see also Binder and Wiek, 2001; Wiek and Binder, 2005).

Table 1: Steps of SSP adapted to sustainability assessment of agriculture (after Wiek and Binder, 2005).

Step	Description	Related methods and literature
Prerequisite		
	Analyzing the stakeholders involved Defining and balancing the goals of different stakeholders	Agent analysis: Wassermann and Faust, 1994; Conway, 2000; Salgnik and Heckadorn, 2004; Hermanns, 2005; Binder, 2006 Consensus building: Cormick, 1996; Susskind *et al.*, 1999
Module I: Systemic Module		
Step 1	Characterizing the region to be assessed	Grosskurth & Rotmans, 2005

Step	Description	Related methods and literature
Step 2	Problem-oriented derivation of indicators Divide into ecological, economic and social indicators Divide into regionally explicit and general indicators	Smith and McDonald, 1988; Bossel, 1999; Linser, 2002; Zhen and Routray, 2003
Step 3	Analyzing the inter- and intra-linkages among the indicators as well as their dynamics	Qualitative System Analysis: Vester, 1988; Bossel, 1999; Scholz and Tietje, 2002; Grosskurth and Rotmans, 2005; Lang *et al.*, 2006; Wiek *et al.*, in press
Module II: Normative Module		
Step 4	Specifying the sustainability ranges for the indicators	Bossel, 1999
Module III: Integrative Module		
Step 5	Identifying conflicts among the sustainability ranges	Consensus building: Cormick, 1996; Susskind *et al.*, 1999
Step 6	Defining the solution space for decision-making	Consistency Analysis: Tietje, 2005

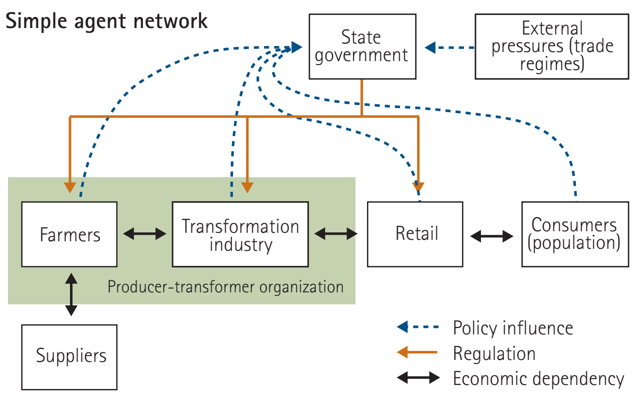
3. Transdisciplinary development of a Sustainability Solution Space

This section focuses on describing the role of a transdisciplinary approach for: (i) accounting for multi-functionality and multiple goals; (ii) selecting indicators; and (iii) defining what is sustainable, (analysis of the normative criteria) within the frame of the Sustainability Solution Space method.

3.1. Accounting for multi-functionality and multiple goals in sustainability assessment

Multi-functionality and multiple goals in sustainability assessment are already considered in the prerequisite phase of the construction of an SSP. On this basis, the research and results ought to be pursued in a society- and policy-relevant framework. To achieve this, it is necessary to understand and include the diversity of viewpoints of the stakeholders and decision-makers while initiating and conducting research, as well as in the presentation of research results (Levy, Hipel *et al.*, 2000; Korhonen, 2004). Transdisciplinary research methods allow for this. In the prerequisite phase, transdisciplinary methods can be applied to: (i) identify the relevant (direct and indirect) agents (Salganik and Heckathorn, 2004); (ii) map their relations through functional (Hermanns, 2005) or production-consumption (Maier Begré and Hirsch Hadorn, 2002) interactions; (iii) map their (diverging) problem perceptions (Mingers and Rosenhead, 2004); and (iv) define the (multiple) goals of the sustainability assessment (Scholz *et al.*, 2006). The following assessment procedure highly depends on who will be utilizing the results. A farmer is likely to set different priorities than the regional administration or a national politician. Furthermore, knowing the networks the different agents are involved in gives insight into potential options and restrictions for change (Binder, 2006) (Figure 1).

Figure 1: A simple agent network, including different types of relations, for the case of Swiss agriculture; note the lack of direct links between producers (farmers) and consumers (Steinberger and Binder, 2006).



3.2. Selecting indicators

In Step 2 of the SSP process (Problem-oriented derivation of the indicators), we propose that the indicators be selected based on the characterization and the problems existing in the selected region or in the agricultural sector. Important criteria for the selection of indicators should be (Binder and Wiek, 2001; Scholz and Tietje, 2002; Zhen and Routay, 2003; Wiek and Binder, 2005):

- *goal orientation* – the indicators have to depict the goals of the stakeholders as defined in the pre-phase of the SSP process (prerequisites phase).
- *data availability* – the indicators have to be easily measurable; and
- *system correspondence* – the indicators have to represent the system adequately.

Regarding the latter, the indicators furthermore should allow for (Dale and Beyeler, 2001; Zhen and Routay, 2003):

- analyzing stress within the system;
- depicting possible damages in advance; and
- integrating different aspects of an issue (e.g., combine several ecological aspects of agriculture).

The transdisciplinary process at this stage comprises brainstorming workshops for identifying preliminary sets of indicators from different perspectives, prioritization of indicators for selected regions by different stakeholder groups, and validation of the selected indicators for the specific area. However, a transdisciplinary process also requires a scientific complement (Gibbons *et al*., 1994). This means that the indicators defined during the brainstorming process have to be carefully revised by the researchers following principles based on system-theoretical approaches and concepts of sustainable development (Bossel, 1999; Robot, 2002; Wiek and Binder, 2005).

Regarding agriculture, even though authors mostly agree on which indicators might be viable for characterizing the ecological and economic aspects of an agricultural system,[2] little agreement exists on how to determine and define social indicators.

We consider that social indicators can be divided into culture dependent and culture independent indicators. The first ones are comparable among countries and continents, the second have to be adapted for specific political and cultural backgrounds (Lefroy *et al*., 2000).

Culture independent indicators

We suggest that these indicators be comparable among countries. Examples of such indicators are (Würtenberger *et al*., 2006):

2 Please note: authors do agree on the indicators but not on which values are sustainable (see also Zhen and Routay, 2003).

- living from farming/farm income – ratio of agricultural income to the countries poverty line;
- living from farming/stability from farm income – standard deviation of the value added of a product;
- rural-urban justice – ratio of farm-income to non-farm income; and
- international justice – difference in revenues of a specific product in a country and average revenue for that product.

A less adequate indicator in our opinion would be: working hours vs. leisure hours (Mann and Gazzarin, 2004). One can compare the hours but—apart from culturally differing concepts of time—in different cultural contexts, working hours as well their perception of the sustainability vary (Levine, 1997).

Culture dependent indicators

These indicators have to be adapted in their definition and data requirements to the different cultures and sub-cultures. They might relate, for example, to social security, the probability of staying in an agricultural activity, or linkage to other parts of the food chain. Furthermore, vulnerability, risk perception and knowledge are indicators that are related to social sustainability and are likely to differ significantly among countries (Smith and McDonald, 1998; Viklund, 2003).

3.3. Defining sustainability ranges for the selected indicators

Sustainable development is a widely applied concept. At the UNCED conference in Rio in 1992, sustainable development was defined as "*economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987). Since Rio, scientists and decision-makers have tried to operationalize and put this concept into practice. Within science, three main interpretations of sustainability can be encountered (Laws *et al.*, 2002): (i) sustainability is an ethical relationship; (ii) sustainability is the maintenance of a system within functional limits; and (iii) sustainability is a form of ongoing inquiry (Binder, 2005). This implies that sustainability is a dynamic concept and that it can be interpreted differently across cultures, as mentioned above (Lefroy *et al.*, 2000; Zhen and Routay, 2003).

In Step 4 of the SSP process (specifying the sustainability ranges for the indicators), we account for this circumstance by defining sustainability ranges rather than precise numbers for sustainability. In defining the ranges, we suggest again a transdisciplinary approach by using available values as defined by governmental policies, and we use expert interviews and workshops to obtain consensus values regarding topics where no guidelines exist (Cormick, 1996; Susskind *et al*., 1999).

4. Discussion and conclusions

To achieve sustainable development in agriculture, sustainability assessment is required to guide strategy-building and subsequent actions. Systemic assessment approaches prove to outmatch approaches that rely on lists of isolated indicators or that remain in the monitoring stage without assessing the current stage and future options based on the available normative knowledge (including preferences and values). Exemplarily, this paper presented as a systemic assessment approach the Sustainability Solution Space (SSP) method. As a crucial component of reliable and valid sustainability assessments, the adequate involvement of stakeholders and decision-makers has been vividly discussed in the scientific community over the last two decades. Thus, the paper explores how extensively transdisciplinary approaches can be adopted for the SSP method in the field of sustainability assessment in agricultural science. We showed that this method allows for:

- including culture-specific system aspects;
- setting culture-specific sustainability values;
- analyzing the interaction among indicators within regionally specific areas; and
- developing strategies for improving sustainability.

Considering the partly exaggerated enthusiasm for participation and involvement, we would like to draw attention to transaction costs for collaboration and coordination in transdisciplinary research. From our experience it seemed to be most valuable to set up a facilitator moderating and mediating the process of problem-oriented transdisciplinary collaboration (van de Kerkhof and Wierczorek, 2005). The role of the facilitator is to ensure an effective and efficient process aimed to keep the transaction costs of collaboration and cooperation low. Otherwise, the willingness-to-cooperate will shrink or even come to a halt. Regarding transaction costs, it is important to note that the proposed SSP approach promotes and supports cooperation and coordination based on a careful evaluation, whether problems identified should be tackled in transdisciplinary, less-participatory (e.g., consultative) or non-participatory settings.

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Farm-level Indicators of Sustainable Agriculture

Classification and description of farm recommendation units for extension impact assessment in Koru, Kenya

Washington Odongo Ochola, Rose Mwonya, Lincoln Ireri Mwarasomba and Matthew Muli Wambua

W. O. OCHOLA – Department of Agricultural Education and Extension, Egerton University, P.O. Box 536 Njoro, Kenya.

R. MWONYA – Department of Home Economics and Human Ecology, Egerton University, P.O. Box 536 Njoro, Kenya.

L. I. MWARASOMBA – National Agriculture and Livestock Extension Program (NALEP), Ministry of Agriculture, P.O. Box 30028, Nairobi, Kenya.

M. M. WAMBUA – NYS, Yatta School of Agriculture, P.O. Box 16/90124, Kithimani, Machakos, Kenya.

Abstract

Decisions concerning land management at the farm level are important for the present and future status of land resources. Sustainable land management (SLM) requires the ability to monitor changes in agro-ecosystems health. Agricultural sustainability indicators (ASI) are useful to this end. This paper documents the application of a generic agricultural sustainability assessment (ASA) framework applied to a small agricultural area in Koru, Kenya. The procedure has been implemented through an agricultural sustainability assessment decision support system (ASADSS), whose functionality has been extended through spatial analysis and geostatistical methods. ASIs are conceived through scientific definition and farmer-based methods. A farm sustainability index (FSI) is computed for the classification of farm units and the subsequent monitoring of impacts of agricultural extension at the farm level. The procedure uses the farm attributes of soils and topography, water resources, land cover, climate, farm management, environmental hazards as well as socio-economic factors. The series of maps generated highlight not only the level and distribution of degradation but also improvements in land condition under different land use and agricultural extension protocol. They can be used to identify "hot spots" and "flush" points of good farm sustainability. While the study reports mainly realistic farm sustainability classes in agreement with variables based on indicators in the field, more specific point-based or fine-scale thematic maps could be generated with the same procedure deeply coupled with GIS interpolation techniques. This would be developed into a dynamic geographical information system (DGIS) for farm sustainability assessment based on spatial and temporal modelling and simulation in an endomorphic system to allow extended participatory farm sustainability assessments and predictions including integrated agro-environmental assessment.

Keywords: Farm recommendation unit, Kenya, Koru, agricultural sustainability indicators, agricultural extension, spatial assessment, sustainable agriculture.

Introduction

Agriculture, which provides about 30 per cent of the GDP of Kenya, is practised in less than 30 per cent of the country's area of 583,000 km^2. This leaves a large part of the country under heavily degraded landscapes and puts increasing pressure on the arable districts inhabited by more than 80 per cent of the population. The condition of the arable environments in the country is, therefore, crucial to sustainable agricultural production. The pressure resulting from intensive farming, increasing population and other forces of environmental degradation may require a methodology to assess the status of such agro-ecosystems. The ability of any farm unit to sustain arable agriculture while preserving its environmental status, referred to in this paper as agricultural sustainability is best monitored by agricultural sustainability indicators (ASI) which are quantitative or qualitative measures, pointers, attributes or descriptors representative of the agro-ecosystem condition and which convey information about the changes and trends in it. The changes are used to assess impacts of agricultural extension. Indicators are useful for both *ex-ante* and *ex-post* assessment (Pieri *et al*., 1996) of the sustainability of land management practices as well as in monitoring changes in the status of agro-ecosystems health. Sustainability of farm systems based on their environmental soundness, economic viability and social acceptability can be used to assess the impacts of agricultural extension (Rasul and Thapa, 2003).

Sustainable land management (SLM) rests heavily on the maintenance of the inherent agro-ecosystems integrity, in turn affected by soil quality and the quality of other land resources. To understand efforts by extension service delivery towards sustainable agriculture, indicators are needed to assess farm sustainability. The aim, primarily is to enhance the ability of scientists and land managers to prevent land degradation, an undesirable outcome of unsustainable land management and negative land biophysical processes such as erosion and other forms of land degradation. Land degradation accelerated during the past decades despite efforts to reduce it. Many of the past attempts to understand degradation have focused mainly on biophysical factors. There is, therefore, a need to consider also socio-cultural and economic dimensions apart from biophysical elements only when addressing sustainable agriculture. Analyses and solutions must be location-specific in terms of biophysics, socio-economics, politics and even gender. To this end, conceptual frameworks would suffice. Although indicators are already in regular use in many areas and disciplines, those which evaluate changes in land resources quality at farm, national or regional levels still need to be refined. The challenge lies with the ability to select indicators that are significant descriptors of the status and trends of farms as agro-ecosystems and are related to the processes caused by various land management practices (Eswaran *et al*., 2000) and can be used in evaluating impacts of agricultural extension services. A desirable feature of an LQI is its ability to quantify and simplify information in such a way that its use in farming and the extension-service decision-making process is clear, while allowing variations within and between farm systems to be easily discernible and predictable.

Although Kenya was used extensively by FAO for studies on land evaluation (FAO, 1976 and 1984) and agro-ecosystems zoning (FAO/IIASA, 1991), LQI development is still in its early stages. Globally, some promising work has been done with respect to concept definition and framework development (Bouma, 2002; Dumanski and Pieri, 2000). Kosmas *et al*. (2000) and Kosmas *et al*. (1999b) used some key indicators or land parameters for defining environmentally sensitive areas (ESA) to desertification in Greece. The integration of participatory land management approaches in land-use planning techniques and farm sustainability assessment has not been previously attempted in Kenya with present indicators. The work by Murage *et al*. (2000) provided a diagnostic analysis for soil quality but did not conceive an approach for the integration of GIS-based multi-variate farm sustainability diagnosis. Elsewhere, other farm sustainability indices diagnoses like the study by Mandal *et al*. (2001) in India have been crop-specific and site-specific, offering little room for prediction and interpolation for wider agricultural sustainability and extension impact assessment. This paper presents the use of farm level indicators to assess sustainable agriculture and extension impact using the platform of farm sustainability assessment decision support system, an interactive spatial tool for farm classification (Ochola and Kerkides, 2004).

Agricultural sustainability assessment

Farm sustainability and need for agro-ecosystems sustainability assessment

The functions of land are diverse (FAO, 1995) and include: (1) production; (2) environmental biodiversity maintenance; (3) climate regulation; (4) regulation of the storage and flow of surface and ground water resources; (5) storehouse of raw materials and minerals for human use; (6) waste and pollution control; (7) provision of physical living space; (8) archive or heritage; and (9) provision of connective space. The qualities and limitations of any land unit are based on these functions. The assessment of the quality of any land unit must, therefore, use methods that measure the ability of the land unit to sustain the targeted function. Assessments of farm sustainability should be objectively made in relation to issues of agricultural sustainability. This, however, depends on the objective of the assessment and the scale of interest. The measurement of the sustainability of agro-ecosystems at the farm level is feasible (Gomez *et al*., 1996; Hurni, 2000; Sulser *et al*., 2001; Wiren-Lehr, 2001).

FAO (1976, 1984) also recommended some generic steps for land evaluation and land-use planning for different uses. The steps have been adopted by many studies particularly those for land suitability assessment (Bydekerke *et al*., 1998; Kollias and Kalinas, 1999; Kalogirou, 2002). Studies on farm sustainability assessment procedures are still at the infancy stage though notable achievements have been made (Bouma, 2002; Bouma and Droogers, 1998; Dumanski *et al*., 1998; Dumanski and Pieri, 2000; FAO *et al*., 1997; Kirkby, 2000; Pieri *et al*., 1996; Steiner *et al*., 2000). SLM aims at harmonizing the complementary goals of providing environmental, economic and social opportunities while maintaining and enhancing the quality of land resources (Smyth and Dumanski, 1993). This harmony defines agro-ecosystems health.

The process and function of indicator development is aimed at finding descriptors for land biophysical processes such as erosion, crusting, runoff, compaction and salinization, fertility status, soil water status, input balance and other land management operations. Vo Wiren-Lehr (2001) has identified three main drawbacks to practical agricultural sustainability assessment: (1) the lack of systemic and transferable indicators which characterize agricultural and other ecosystems; (2) the deficit of an adequate evaluation of agro-ecosystems; and (3) the lack of principal guidelines for the formulation of management advice for practical application. The challenge is to select and define indicators that are significant descriptors of the status and trends of agro-ecosystems quality and are related to the processes caused by various land management practices (Eswaran *et al*., 2000). To this end, both qualitative and quantitative indicators can be identified, defined and used to assess farm sustainability. Qualitative indicators should be used to backstop, streamline and develop quantitative indicators of farm sustainability.

Indicators and sustainability assessment

If carefully crafted using transparent and standardized but flexible (scale and function dependent) protocols, agricultural sustainability indicators would be used for policy formulation, program development, environmental impact assessment and to promote technologies, policies and programs that ensure better use of natural resources and SLM. As pointers, indicators, when used effectively can flag important conditions and trends that can support agro-ecosystems planning and decision-making. Indicators enhance the ability of land users to:

- develop and use better land information gathering and reporting systems;
- integrate environmental, social and economic attributes of a land system; and
- report regularly and reliably on the state and trends of land resources.

ASIs fall in the larger family of frameworks for natural resources assessment (FAO *et al*., 1997). The frameworks serve to organize the large quantities of resource management domain data for the development of indicators as well as promote their wide-scale use. Some frameworks have been developed in structures and formats that help measure the impacts of agriculture on the environment, like the logical framework approach (Uribe and Horton, 1993), the framework for evaluating sustainable land management (FESLM) described by Smyth and Dumanski (1993), technological changes assessment (Porter, 1995), life cycle assessment (LCA) (Jonson, 1996) and environmental impact assessment (Petts, 1999). The pressure-state-response (PSR) framework, development by the World Bank (Dumanski and Pieri, 1997) is useful for environmental reporting. It links *pressures* on the environment as a result of human activities with changes in the state (condition of the environment—land, water, air, etc.) as well as the feedback (*response*) due to societal interventions to restore the state of the environment. The PSR framework has been applied in the development of several environmental indicators (Dumanski, *et al*., 1998; OECD, 1997, 2000).

Indicators abound in many forms (raw data, qualitative data, composite indicators and indices, textual information, etc.) so there is a challenge of selecting and implementing relevant and practical indicators. Although agro-ecosystems are composites of biological, environmental, economic, social, institutional and political systems, few indicators are representative as many are sectoral. Indicator effectiveness may also be undermined by the dilemma of scale. The relevance and applicability of different indicators depend on the level of scale (Riley, 2001) and the perception of the land managers at each scale. Approaches to integrating complex facets into indicator definitions have been presented by other researchers (Pretty, 1995; Halberg, 1999). The proposed use of resource management domains (RMD) by Eswaran *et al*. (2000) treats scales as biophysical units ranging from farm to agro-ecological zones for assessing and monitoring farm sustainability. The RMD represent the focal areas used as extension units in Kenya. Stein *et al*. (2001) have presented approaches to down-scaling and up-scaling environmental indicators and have used geostatistical methods to determine the most appropriate scales for environmental indicators in space and time. Issues of scale have also been addressed by Bouma *et al*. (1998).

Since indicators play succinct roles in the assessment of farm sustainability and sustainable land management, the procedure adopted for obtaining them must be empirical and transparent. It is also prudent to consider spatial and temporal elements of farm sustainability, as indicators and threshold values are influenced by scale (field, farm, watershed, region, continent, global and time—days, growing season, years, decades or centuries) (Bouma *et al*., 1998). The integration of socio-economic issues in farm sustainability assessment is gaining equal impetus. By using participatory approaches (Martin and Sherington, 1997) such as participatory rural appraisal (PRA), participatory monitoring and evaluation (PM&E) and participatory impact assessment (PIA), social issues are almost integrated by default. Socio-economic factors are instrumental in LQA since science knowledge plays an important role in the assessment, but no more so than human values and actions. Bland (1999) argued for an integrated assessment method (IAM) for agricultural systems. Integration of socio-economic issues in farm sustainability assessment protocols is not only morally appealing but is the missing link to assessing sustainable agriculture, particularly in developing countries.

The study area

Site selection was done after a socio-cultural study of the wider Nyanza province in which Koru area falls (Ochola *et al*., 2000) and by drawing on preliminary indicators of agricultural sustainability and land degradation for an ongoing farm sustainability assessment work in Kenya. The area is around Menara in the Muhoroni division of Nyando district. The area is not representative in the statistical sense, but it is a typical case of focal areas targeted by the Ministry of Agriculture and Rural Development in its newly integrated approach to agricultural extension (NALEP, 2000) using the shifting focal area approach (SFAA) of agricultural extension. It was crafted out of the wider settlement scheme based on indicators succinct to the delineation of resource management domains (RMD), a definition which has been given by Eswaran *et al*. (1998) as a geographical area that is homogeneous with respect to defined agricultural uses with similar physiographic boundaries and similar farm sustainability characteristics.

The part of Koru area used in the study (about 36°00'E and longitude 0°25'S) has an area of about 18 km^2 and is located 350 km west of Nairobi (Figure 1). The altitude varies between 1,240 and 1,450 m above sea level with annual precipitation ranging from 1,100 to 1,350 mm, with bimodal pattern (Figure 2). The long rains fall during the April to July spell, while the short rains are experienced from September to November. The average temperature is 22.5°C and the natural vegetation is largely composed of tropical deciduous trees, although this has been largely modified through expansive agricultural crops cultivation. The main cash crops are sugar cane (*Saccharum officianarum,* L) and coffee (*Coffea arabica*). Maize (*Zea mays,* L) is the chief food crop which is grown twice in one calendar year. The soils in the area are predominantly vertisols and it falls in the agro-ecological zones II and III, with moderate suitability for rain-fed crop production (FAO/IIASA, 1991).

The area is largely characterized by irregular topographic structure with steep slopes, undulating and gentle terrain within short distances. The principal communities living in the area are mainly Luo settlers originally from other parts of Nyanza province having acquired the land through cooperative societies or individual purchase. The selected site consists of 255 family holdings with an average size of 15–20 acres.

Figure 1: Location of study site in Kenya.

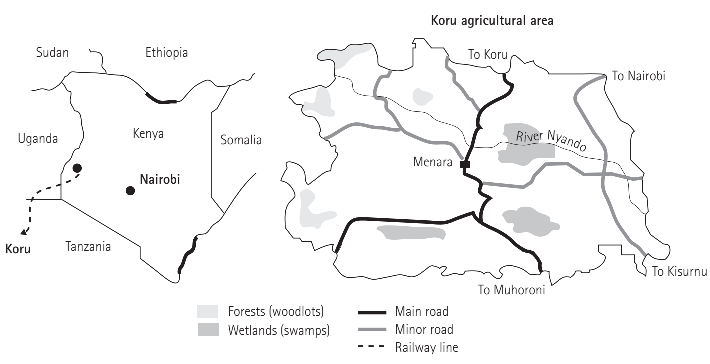
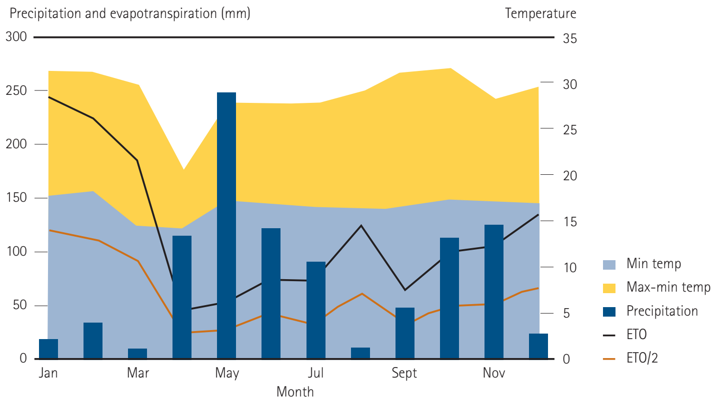


Figure 2: Climate diagram for Koru area.

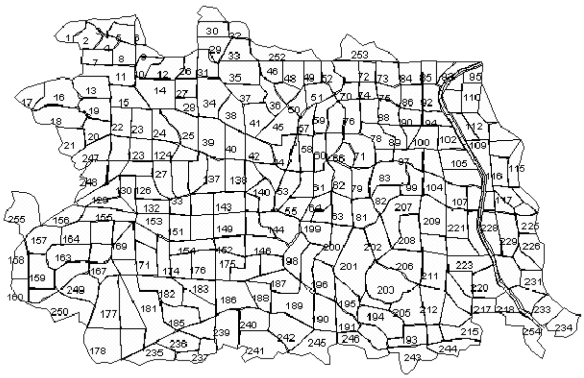


Materials and methods

Delineation of farms and mapping

The study used individual farm holdings as the basis of the assessment procedures. This was in agreement with the hierarchies and land management unit attributes proposed by Eswaran *et al.* (2000). The maps were based on survey maps obtained from the office of the Ministry of Agriculture and Rural Development and updated by participating farmers during consultative sessions in the field. The map that was eventually used for Koru area does not represent any administrative zone but is a conglomeration of adjacent farm holdings for which adequate land-use information was available to enable meaningful farm sustainability indicator development and subsequent geo-processing. The maps were also compared with adjudication documents at the local cooperative society office. The maps were then digitized for use in ArcGIS at the scale of 1:50,000. Eswaran *et al.* (2000) propose scales of between 1:1,000 to 1:5,000 for farm level assessments and 1:25,000 to 1:250,000 for RMD assessment at catchment or focal area levels. The scale was chosen for farm unit specificity and to render the resulting overlay maps amenable to other basic agricultural extension activities and as well as other forms of agro-ecosystems modelling. The farm units, which represent the farm recommendation units (FRUs), were then numbered sequentially to represent the order of assessment and for labelling household level resource management. For the current study site the labels "FRU001," "FRU002," … to "FRU256" were used. Figure 3 shows the delineated farm units in the area.

Figure 3: Delineated farm recommendation units as basis of the sustainability assessment.



Data collection and processing

The study used a double track approach for the collection and collation of the data sets. Secondary data about the study site including climate data from 1981 to 2004 (daily precipitation, daily minimum and maximum temperature and daily evapo-transpiration), soils and topography, land cover characteristics, water resources features, environmental hazard conditions, land management information and socio-economic characteristics were obtained from existing literature and databanks of organizations and government departments in Muhoroni division. To gauge farmers' perceptions of the quality of their land, participatory mapping and focus groups as well as individual interviews were conducted. The map of the area was geo-referenced at 1:50,000 scale. The integrated transect analysis (ITA) tool (Gobin, 1998) was used to capture area-wide agro-ecosystems features along different topo-sequences. Data on soils, water resources, land cover and other aspects of land management used to define and parameterize the indicators were also gathered through field visits and a survey conducted with the help of agricultural extension officers from Menara office. This was guided by a semi-structured interview (SSI) checklist and a series of participatory rural appraisal (PRA) discussion fora. The yields of sugar cane for the last 10 years were obtained from the cooperative society office and confirmed by individual farmers during farm visits.

The farm sustainability assessment procedure

The research chain used in the delineation, classification and description of agricultural sustainability at the farm recommendation level followed these guidelines:

1. delineating the area (farm, region or country) into distinct units (farm units, AEZ or parcels);
2. selecting the delineated units with similar land attributes (biophysical and socio-economic);
3. defining the goal or requirements for the sustainability assessment such as: agricultural extension impact assessment, farm performance assessment, farm sustainability assessment, land degradation and environmental vulnerability assessment (EVA) or land suitability assessment;
4. selecting the indicators to use in the key indicator suites for the delineated units. Some indicators can be used as integrators and for assessment framework validation;
5. specifying the critical limits of the selected indicators;
6. transforming the indicators into indices based on data about land attributes;
7. applying the indices to the agricultural sustainability assessment framework; and
8. identifying the limitations to farm-level agricultural sustainability and associating them with the agricultural extension objective, then suggesting sustainable land-use solutions including extension interventions.

Research chains in combination with geostatistical methods have previously been applied in obtaining soil and land quality indicators (Hoosbeek and Bouma, 1998). The methodology of farm sustainability assessment and soil erosion risk estimation of CORINE (EU, 1992; Kosmas *et al*., 1999) was adopted, with several modifications to suit the area and its data endowment, for the composition of the indices. The approach systematically translates land resources attributes into indices and classes. Several attributes are grouped into seven major indicator suites composed of related land and environmental characteristics. Table 1 gives an example of the land cover quality indicator suite. A similar classification approach was used for all the other indicator suites. The categorization system for all the indicator suites is shown in Table 2 showing specific land attributes that compose them. The indicators were evaluated for their usefulness in the assessment using the evaluation guidelines for ecological indicators (USEPA, 2000) and on the assumption that there is a significant inter-dependence relationship among them (Arshad and Martin, 2002).

Table 1: Land cover quality indicator classification.

Land cover attribute	Attribute range				
	Very low 1	Low 2	Moderate 3	High 4	Very high 5
% Land cover	< 10%	10– 25%	25–50%	> 50%	–
Drought Tolerance	BL	AC AG DAL	PC	DF MF CF	TF PG SG BF
Fire risk	MF	AC DAL	PC BL BF	TF PG CF	AG SG
Vegetation Type	BL	AC AG SG DAL	PC PG	DF MF	CF TF BF

LEGEND: AC–Annual crops; AG–Annual grassland; BF–Bamboo forest; BL–Bare land; CF–Coniferous forests; DAL–Derived agricultural land; DF–Deciduous forests; MF–Mangrove forests; PC–Perennial crops; PG–Perennial grassland; SG–Savana grassland; TF–Tropical forests

Table 2: Categories of indicator suites.

Indicator suite	Component attributes (Indicators)
Soils and topography	• Soil depth, • Soil texture, • Soil drainage, • Slope, • Erosion status
Water resources	• Water resource variability (Type), • Water resource utilization, • Water resource hazards, • Water resource quality problems, • Water resource productivity
Vegetation and land cover	• Vegetation type, • Percentage land cover, • Drought tolerance, • Fire risk

Indicator suite	Component attributes (Indicators)
Climate	• Rainfall amount, • Rainfall variability, • Aridity, • Drought incidence, • Length of the growing period (LGP) based on local maize cultivars, • Agro-climatic zone
Land management and improvement	• Land use type (LUT), • Land use intensity (LUI), • Land improvement
Environmental hazards	• Floods, • Land slides, • Winds, • Frost, • Temperature extremes, • Rainfall extremes, •Hailstorms, • Human and livestock diseases, • Crop pests and diseases, • Air and water pollution, • Fire risk
Socio-economic issues	Economic viability • Land holding, • Net farm income, • Off-farm income, • Farm labour availability, • Percentage farm produce sold, • Difference between market and farm-gate prices, Socio-cultural acceptability • Land tenure status, • Existence of title deed, • Access to extension services, • Training on conservation, • Access to social amenities (schools, health facilities), • Road links to major roads, • House hold size and type, • Socio-cultural limitations and concerns (gender, taboos, etc.)

These attributes constitute the indicators on which the farm-level agricultural sustainability assessment procedure is based. The methodology proceeds in three phases. Phase I involves the determination of potential farm sustainability index and classes based on classes and indices of soil, land cover, water resources and climate qualities. Phase II computes and classifies, using Boolean classification method, the actual farm sustainability indices. Phase III involves the use of land attributes data and the results of analysis in phases I and II to spatially analyze the quality of land and land resources in the area through GIS. At each stage and phase of the procedure an index is computed based on the function below.

$$f(X) = (x_1 \times x_2 \ \dots \ x_n)^{1/n} \qquad (1)$$

where $f(X)$ is the combined index for farm sustainability indicator suite X, x_1 is the land attribute i and n is the number of land attributes that define the indicator suite. For instance the overall climate quality index (*CQI*) is determined thus:

$$CQI = (RAI \times RVI \times ARI \times DII \times GPI \times ACI)^{1/6} \qquad (2)$$

where *RAI* is the rainfall amount index, *RVI* is the rainfall variability index, *ARI* is the aridity index, *DII* is the drought incidence index, *GPI* is the growing period index and *ACI* is the agro-climatic index based on the agro-climatic zoning scheme (KSS, 1982). A similar indexing approach was used in the CORINE farm sustainability and erosion risk assessment project (EC, 1992; Kosmas *et al*., 1999). The resulting indices are then converted into classes using the linear interpolation function below.

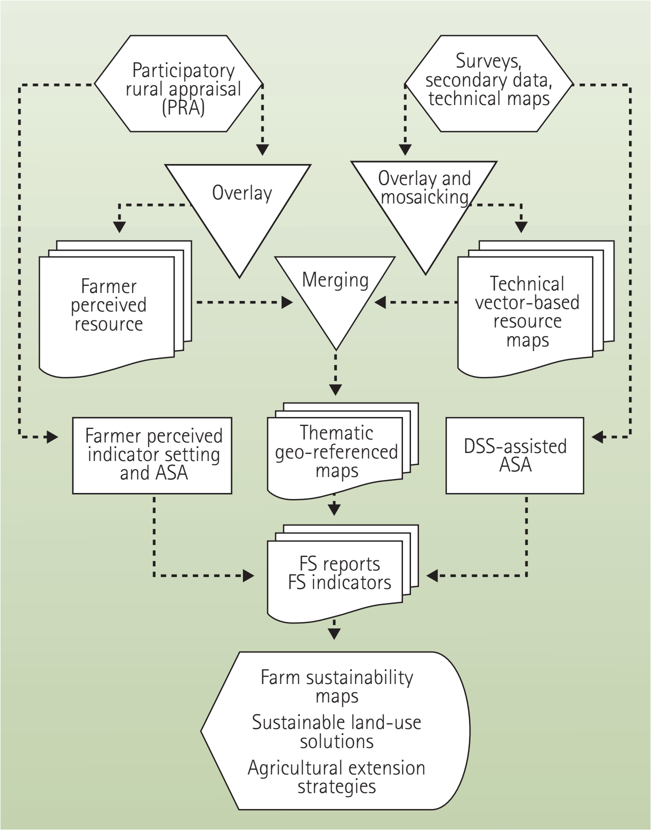
$$y = \frac{(d - c)}{(b - a)} \times x + c - \frac{(d - c)}{(b - a)} \times a \quad (3)$$

where *y* is the attribute class, *x* is the attribute value or index, *a* and *b* are the lower and upper limits of the attribute value or index and *d* and *c* are the lowest and uppermost attribute classes respectively. The function was also used by Kalogirou (2002) to classify land suitability. At each stage limitations to sustainable agriculture are identified based on threshold levels (Arshad and Martin, 2002) set for each indicator or farm attribute. Responsive farm management actions are set based on these limitations and appropriate extension messages designed.

Spatial analysis

The various spatial and non-spatial data from the parallel data collection methods were harmonized, digitized and labelled then linked with tabular data recorded about the attributes in ArcGIS (ESRI, 2001). The overall mapping methodology shown in the flowchart (Figure 4) was employed to generate several thematic maps. For purposes of understanding spatial significance of farm sustainability parameters and to establish the magnitude of farm sustainability attributes and spatial distribution of the attributes in the study area, geostatistical techniques were used. Spatial interpolation techniques that allow analysis and mapping of the extent and spatial variability of the farm sustainability indicators and limiting factors were used. From a land management point of view, this approach not only provides information about the spatial distribution of the indicators, but also gives necessary clues to the magnitude of the efforts and land management practices needed to address the farm sustainability limitations. Ordinary kriging techniques (ESRI, 2001) were used to predict the indicator values for parts of the mapping units where indicator measurements were not available.

Figure 4: Spatial analysis and GIS integration procedure.



ArcGIS's Spatial Analyst and Geo-processing extensions (ESRI, 2001) were then used to refine the spatial and geostatistical analysis and to query the maps and their related attribute tables and data sets for specific farm sustainability assessment goals. The sustainability assessment goals were based on opportunities for sensitivity analysis and predictions. These were done to better represent the qualitative and quantitative aspects of the vector data. There were no attempts made at this stage to convert vector to raster data formats. The assessments ranged from spatial variations between farm units and within a resource management domain to intra- and inter-variable (indicator) analysis to explore indicator effectiveness for predictions and sensitivity analysis over space. The procedure represented the exploratory spatial data analysis (ESDA) component of the assessment approach. A correlation analysis was also performed between sugar cane yields (tonnes/ha) and the computed farm sustainability indices for the farm units.

Results and discussions

The approach mirrors, in procedure, the farm sustainability index procedure used by Mandal *et al.* (2001) for sorghum (*Sorghum bicolour* L.), which represents a crop-specific analysis with only soil quality and climate quality as key derivatives. The analysis of the spatial distribution of farm sustainability classes indicates that there is a regular relationship between the various land/land resources attributes and the farm sustainability status. There is however no clear spatial pattern of the distribution of the sustainability classes over the study area. The distribution tends to be dictated by the land attributes and is influenced heavily by socio-economic factors and land husbandry. Specific land attributes like slope, drainage and soil depth have their indirect effect on farm sustainability distribution in the area effected by land management and land improvements. The results suggest that the farm sustainability status (and production of sugarcane crop) is influenced by an interaction of several biophysical and socio-economic factors, which have been specified here as farm sustainability indicators. The farm-level agricultural sustainability approach presented in this paper offers opportunity to classify agricultural land with both qualitative and quantitative indicators while integrating spatial analysis and participatory investigation.

Because of the biophysical attributes included, the approach treats potential farm sustainability as the inherent physical quality of land resources for agriculture, and other functions of land as dictated by soils, climate and land cover. Actual farm sustainability is considered as the quality of land under prevailing management conditions and the socio-economic milieu. Table 3 shows the distribution of various farm sustainability classes (FSC) in Koru area. Figure 6 illustrates the results of ordinary kriging (ESRI, 2001) for two forms of farm sustainability based on the spherical model (ESRI, 2001) while Figure 7 shows the land attribute quality prediction maps for the individual farm sustainability indicator suites. In Koru, the potential farm sustainability presents a lower variability compared to the actual farm sustainability. Because of the relatively small area, the physical attributes such as soils, topography, water, climate and elevation do not result in a highly varied farm sustainability. The mapped high variation in actual farm sustainability is the result of land management, socio-economic status and environmental hazards (Figure

5). Most of the farm sustainability limitations concern land-use choices and other human-related factors (Table 4).

Table 3: Proportions of the various farm sustainability classes in Koru.

Farm sustainability class	Potential farm sustainability		Actual farm sustainability	
	No of farms	Percentage (%)	No of farms	Percentage (%)
FSC1: Very high	9	3.53	11	4.31
FSC2: High	86	33.73	147	57.65
FSC3: Moderate	128	50.20	94	36.86
FSC4: Low	32	12.55	3	1.18
FSC5: Very low	0	0.00	0	0.00

The main soil quality limiting factors include soil texture characteristics which affect water balance and erodability as well as shallow soils mainly caused by rampant erosion. They affect over 80 per cent of the farm recommendation units. This on the ground is evident in terms of the extent of eroded landscape in the study area and the prevalence of the siltation of water resources like River Nyando. Land cover limitations include low-level protection against erosion risk and the poor drought resistance characteristics of most of the annual and perennial crops and trees in the area. This affects all land units. The varying level of land improvements in farm infrastructures such as feeder roads, fences and other utilities provide the strongest limitation to improved land management quality, together with the choice of land-use type. Among the key socio-economic factors that limit improved farm sustainability are limited credit facilities for farm investments, inadequacies of social amenities and a host of socio-cultural practices (see also Ochola *et al.*, 2000). The main indicator suites that limit the actual farm sustainability in Koru stand out to be land cover deterioration, socio-economic factors and land management. These limitations offer potential "entry-points" for an integrated intervention aimed at sustainable land-use planning.

Figure 5: Farm sustainability assessment maps for individual farm recommendation units in Koru area.

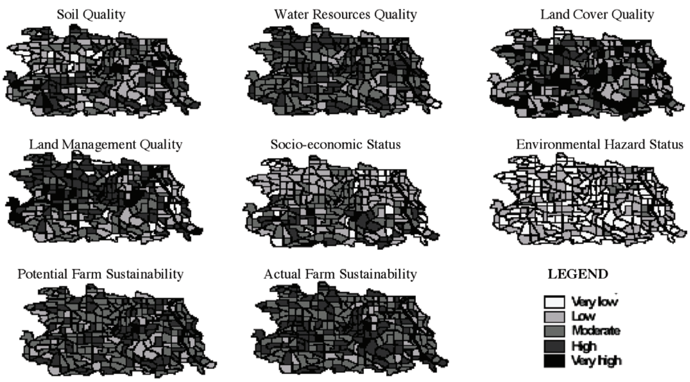
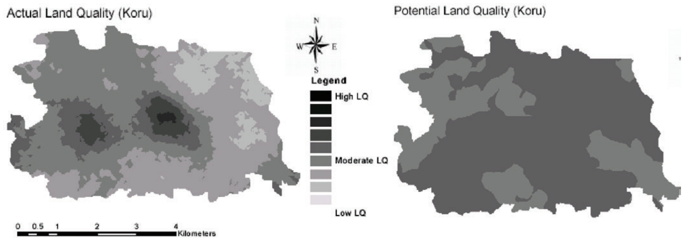
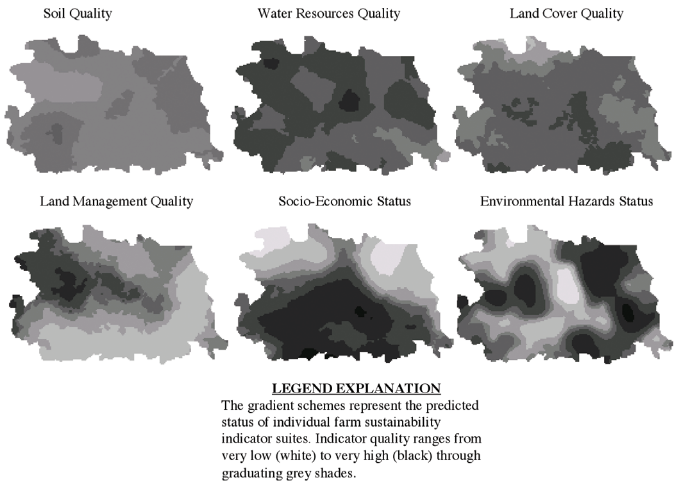


Figure 6: Farm sustainability prediction maps.



The factoring of the actual and potential farm sustainability classes with other standard agro-ecosystems' descriptors like yield of predominant crop (sugarcane) and the size of land holdings (ha) presented an opportunity to cross-check the validity of the framework used in the study as can be seen in Figure 8 and its use in extension impact assessment. There is, at least visually, a close link between the yield of sugarcane andthe actual farm sustainability classes.There is a higher proportion of high and very high farm sustainability classes in the high yield brackets (80–100 ton/ha and over 100 ton/ha) while higher proportions of the moderate and low farm sustainability classes are more prevalent in the lower yield brackets (under 40 ton/ha and 40–60 ton/ha). In contrast,

Figure 7: Farm attribute quality prediction maps.



there is no apparent link between the farm sustainability classes and the sizes of land holdings. In a settlement area like Koru the initial land sizes were almost the same (20 ha) per household. The sizes have over the years decreased due to increasing land subdivision through the sale of portions of land and other socio-cultural obligations (Ochola *et al*., 2000). Land size obviously does not influence sustainable land management. Sustainable land management is heavily reliant on land management strategies and less on land size. The various actual farm sustainability classes seem to be evenly distributed among all land-holding brackets.

There is a significant variation in the statistical quality control of land and land resources attributes in Koru. Figure 9 shows an example of X-bar and R-charts from the analysis. While the R-chart indicates significant variations in actual farm sustainability, the X-bar chart shows that the mean index for actual farm sustainability is under control among the farm units. The farm sustainability and the quality of land attributes are close to or between the lower control limit (LCL) and the upper control limit (UCL). Also, land husbandry, socio-economic factors and environmental hazards are well in the control range. Thus a few limiting factors might be decisive in determining agricultural sustainability. These are indicators of poor land management, which must be removed to secure sustainability. From a land-management point of view, the charts together with the maps (actual polygon feature maps—Figure 6, and the prediction maps—Figure 7), provide information about the geographical distribution of the problem-areas, and also give necessary clues to the magnitude of the efforts and investments needed to improve farm sustainability for specific purposes.

Figure 8: Factoring actual farm sustainability classes with yields and land holding size.

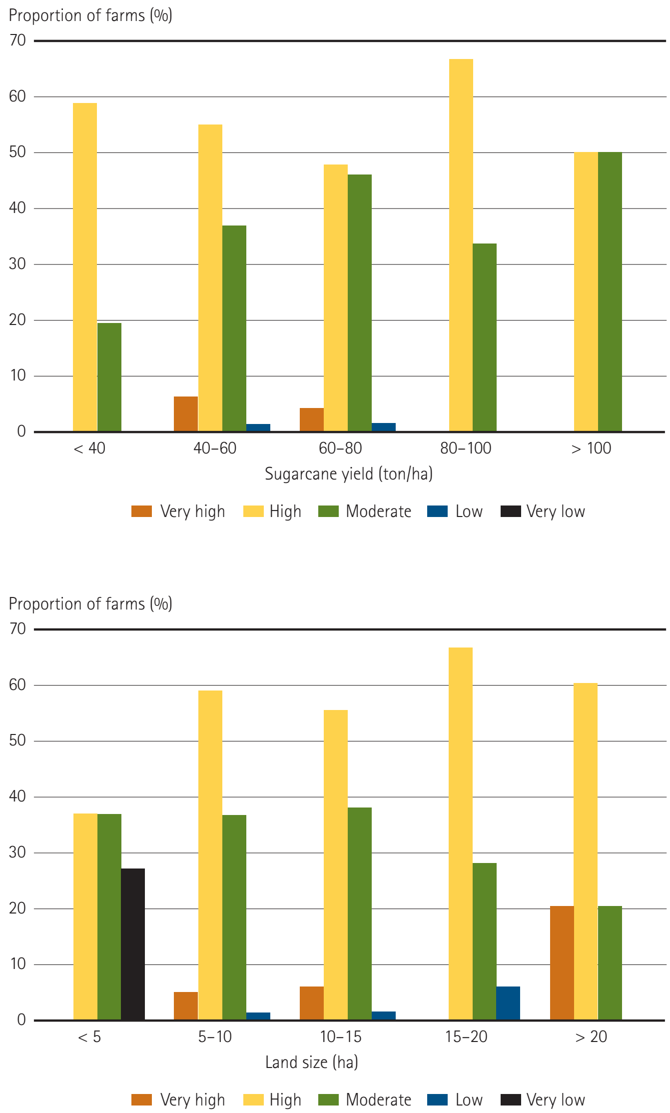
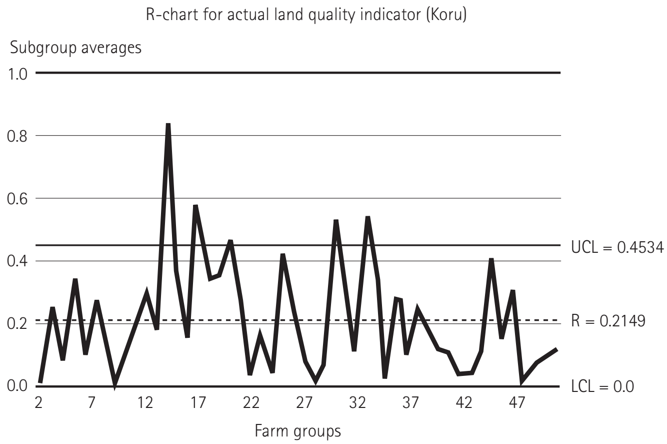
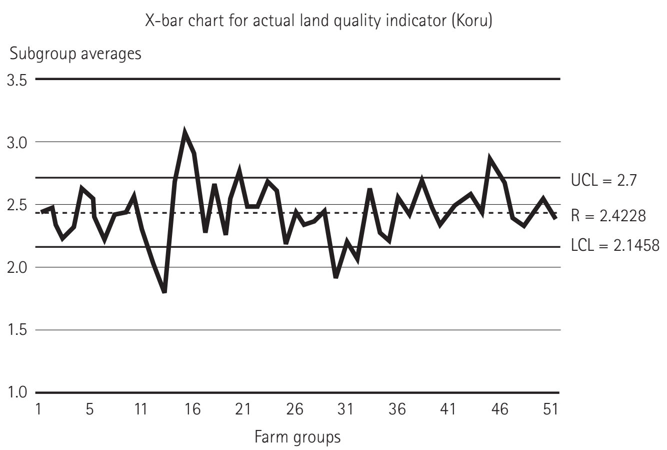


Figure 9: Selected farm sustainability control charts.





The results obtained from the application of control charts and the farm sustainability maps produced via geostatistical analysis were used as data layers and integrated in a geographic information system to obtain information about management-dependent farm sustainability indicators. The maps highlight not only the level and distribution of degradation but also improvements of land condition under different land-use and agricultural extension protocol. They can be used to identify "hot spots" and focal points of good farm sustainability. These are significant to extension workers and farmers in designing appropriate land-use technology transfer strategies for each farm unit. The focal area development plans and farm-specific action plans that form the basis of the shifting focal area approach used by the ministry of agriculture must take these strategies into account.

Conclusions and outlook

The use of farm sustainability indicators to describe and predict agroecosystems health is realistic and can be used to monitor the impact of agricultural extension at the farm and focal-area level. Within the shifting focal area approach used by NALEP, the framework can be used for monitoring and evaluating farm-specific action plans and agricultural practices aimed at improving farm sustainability. Spatial analysis of the resulting information offers even more versatile tools for improved land management as the inherent fragmentation and variations in the quality of soils, water resources, land cover, land husbandry and the effects of socio-economic factors and hazards become clear. Approaches to the use of GIS in participatory decision-making, extension strategy formulation and land-use planning were attempted. This is in line with the context of applying participatory tools, remote sensing and GIS as valuable tools in the process of the planning and management of natural resources, allowing the incorporation of multi-criteria techniques of farm sustainability assessment. Such applications of GIS-based multi-variate analysis for land-use planning have also been presented by Bojorquez—Topia *et al*. (2001) for land suitability assessment and Rybaczuk (2001) for environmental management.

While the study reports mainly realistic farm sustainability classes agreeable with the variables based on indicators in the field, more specific point-based or fine-scale thematic maps could be generated with the same procedure, deeply coupled with GIS interpolation techniques. This was also attempted in the current study, although the initial objective of the farmers was only to get a broad picture of parcel-level farm sustainability and limitations to improved farm sustainability. Prediction maps of farm sustainability and extension impact would offer opportunities to understand farm sustainability characteristics at finer scales within a given land parcel and across a wider resource management domain. Using ArcGIS interpolation techniques like krigging (ordinary, universal, simple, probabilistic, deterministic, indicator-based or disjunctive krigging) and the inverse distance weighted (IDW) techniques (ESRI, 2001), this can be achieved. When combined with satellite images and other thematic maps of land attributes and land resource characteristics, specific results can be achieved for land fertility status, nutrient status, moisture status and soil chemical and physical properties focal area development. These would couple well with ASA and extension impact maps for use in crop specific land suitability assessment, land-use and land-cover research and extension strategy formulation. All in all, these would factor into precision agriculture, which currently is not well implemented in Kenya, and point-based land management recommendations to aid agricultural extension activities and site-specific farmer decision-making in such fragmented-heterogeneous areas like Koru. The introduction of temporal analysis to the approach would offer more meaning to the current GIS approach. This would develop into a dynamic geographical information system (DGIS) for farm sustainability assessment based on spatial and temporal modelling and simulation in an endomorphic system to allow extended farm sustainability assessments and predictions.

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Farm Sustainability Assessment using the IDEA Method

From the concept of farm sustainability to case studies on French farms

Frédéric Zahm, Philippe Viaux, Philippe Girardin, Lionel Vilain, Christian Mouchet

Corresponding author: Frédéric ZAHM, CEMAGREF – Unité Aménités et dynamique de l'espace rural, 50 avenue de Verdun – 33612 Cestas Cedex.

Philippe Viaux, Arvalis – 91720 Boigneville.

Lionel Vilain, FranceNature Environnement, Muséum national d'histoire naturelle, 57 rue Cuvier, 75231 Paris cedex 05.

Philippe Girardin, INRA – UMR Agronomie-Environnement – BP 507 Colmar Cedex.

Christian Mouchet, ENSAR – Laboratoire de Développement Rural – 65 route de Saint-Brieuc – CS 84215 – 35042 Rennes Cedex.

Abstract

Although many indicator sets have been developed to characterize sustainability, a lack of available methods and operational tools to assess the sustainability of a farm is often reported. The use of specific indicators can be an interesting if farmers can use them in a process of self-assessment. First, the French IDEA method (*Indicateurs de Durabilité des Exploitations Agricoles*) of farm sustainability indicators illustrates the scientific approach adopted by the authors in this paper to translate the concept of farm sustainability into a system of 41 sustainability indicators covering three dimensions of sustainability. Secondly, some results are presented from different case studies illustrating tests of the IDEA method. Thirdly, the way of building the indicators is discussed on the basis of some results and feed back from users. In conclusion, a recent work linking the IDEA method with national data bases is noted.

Keywords: IDEA method, sustainability indicator, sustainable agriculture, assessment, farm, method.

Introduction

Although the definition of sustainable development put forward in the Brundtland Report is now generally accepted ("mode of development that meets the needs of the present without compromising the ability of future generations to meet their own needs"), its application in agricultural operations still raises many scientific questions.

Since the United Nations Rio Conference (UNCED, 1992), the European Union has been working to integrate the transversal character of sustainable development into its policies in all the different sectors of activity. The last reform of the Common Agricultural Policy (CAP) (2003) partly expressed the EU's determination to establish sustainable development as one of the guiding principles of European policies by establishing the principle of cross compliance[1] and support for types of agriculture that favour the environment (Article 69 of the CAP regulation N°1782/2003).

The European Commission also supports the elaboration of indicators of sustainability in agriculture with a view first to orient policies in favour of sustainable farming and then to assess them (European Commission, 2000, 2001). However, these political objectives raise the question of the conception of new indicators to evaluate the degree of sustainability of an agricultural production system. How can we go about translating the concept of sustainability into operational terms on the level of individual farms? In France, this question has led to scientific consideration of how to comprehend sustainability through indicators.

In this context, the essential purpose of this paper is to present some results of a French multi-disciplinary research project which has given the concept of sustainability practical expression in the elaboration of the IDEA method (*Indicateurs de Durabilité des Exploitations Agricoles or Farm Sustainability Indicators method*) (Vilain *et al*., 2003). This method, conceived as a self-assessment grid for farmers, provides operational content for the notion of agricultural sustainability.

This paper begins by going over the main concepts underlying a system of sustainability indicators. Secondly, the scientific method developed for the elaboration of the IDEA method is presented, moving from the concept of agricultural sustainability to a system of indicators on the scale of

1 The Sustainable Agriculture Contract is the French contract to subscribe an agri-environmental measure.

the farm. Thirdly, we present the results of different case studies in France using results from different farms surveyed and then discuss different points on the scientific building of the method. We conclude by presenting a few prospects for research.

1. General considerations on sustainability in agriculture and on indicators

The need for a definition is a prerequisite for the elaboration of a conceptual framework for sustainable agriculture

Several definitions of a model of sustainable development exist. In 1988, the Consultative Group on International Agriculture Research considered that "sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources." Harwood defines sustainable agriculture as "a system that can evolve indefinitely toward greater human utility, greater efficiency of resource use and a balance with the environment which is which is favourable to humans and most other species" (1990 in Bonny, 1994). It is the consensual definition given by Francis and Youngberg (1990, in Bonny, 1994), which is today commonly accepted to qualify sustainable agriculture: "Sustainable agriculture is agriculture that is ecologically sound, economically viable, socially just and humane."

We will consider that sustainable farming is based on three essential functions; the function of producing goods and services, the function of managing the territory and the function of playing a role in the rural world. As for the conception of a sustainable farm operation, we propose that given by Landais: "a farm operation that is viable, liveable, transferable and reproducible" (1998).

Applying the concept of sustainability to agriculture leads us to extend the demand for indicators to take the different dimensions of sustainability into consideration

On the level of the farms, the indicators must characterize the key concepts taken from the definition of sustainable agriculture (Zahm *et al.*, 2004).

Viability involves, in economic terms, the efficiency of the production system and securing the sources of income of the farming production system in the face of ups and downs on the market and uncertainties surrounding direct payments. This concept can be analyzed by making a judicious choice of common indicators.

Liveability focuses on analyzing whether the farming activity provides a decent professional and personal life for the farmer and their family. These indicators may place the farmer in relation to certain social references, such as income or working times, for instance, but may also tackle more subjective aspects such as participation in the community and associations or openness to non-farmers, *translating the experience of farmers and the form of relationship they have with society*.

Lastly, *the environmental reproducibility* of the ecosystems linked with the farms can be analyzed using agri-environmental indicators in particular, which characterize the impacts of farming practices on the environment. In most cases, these indicators will provide information primarily on risks for the environment linked with farming activities.

The definitions to qualify an indicator are many, but they are all directly linked to the objective assigned to the indicator. For Gallopin (1997, in OCDE 1999a) indicators are given a wide range of names: variables, parameters, measurements, statistical measurements, indirect measurements, values, indices, meters, empirical models of real conditions and telltale signs. We propose to take as a definition: "indicators are variables that provide information on other variables that are less easily accessible. They also serve as a guide when making a decision" (Gras *et al*., 1989).

Sustainable development applied to agriculture requires indicators to be established combining the following three dimensions:

- *systemic:* this consists of apprehending, at one and the same time, the economic, environmental and social aspects of agriculture;
- *temporal and spatial:* here the purpose is to assess the effects that are likely to occur over time and in space, given that a system that is balanced in appearance can generate imbalance locally or over the long-term; and
- *ethical:* sustainability is founded on a system of values such as the need to conserve natural and human heritage, or at least to use it as sparingly as possible (Vidal *et al*., 2002).

Regarding its expected qualities, an indicator must be objective and scientifically sound, relevant to the issue being studied, sensitive, easily accessible and comprehensible (Girardin *et al*., 1999).

What is the best approach to constructing a sustainability assessment method?

Our purpose here is not to give a detailed presentation of the research questions and the general scientific approach involved in the construction of sustainability indicators. These aspects have already been explained in the specific papers of Mitchell (1995) or Girardin (1999), who propose an approach to constructing indicators in five stages:

1. defining objectives;
2. choosing hypotheses and the most important variables;
3. creating the related indicators;
4. determining the reference thresholds or choosing standards; and
5. validating by testing.

2. How the IDEA method was built

We propose, on the basis of these general principles presented above, to illustrate this approach by presenting a practical case conducted in France: the construction of the IDEA method.

First stage: Explain the principle of sustainability in the form of clearly identified objectives within a conceptual framework

To give meaning to the notion of sustainable agriculture, it is first necessary to transcribe the concept of sustainability into a conceptual model based on clearly identified sustainability objectives. This conceptual stage is indispensable scientifically, because it enables us to state the conceptual hypotheses clearly and therefore to engage debate later. Aside from the necessary conceptual rigour mentioned, this approach has the advantage of being pedagogical by serving as a guide for the user to understand and interpret the indicators that are constructed.

Thus, in the IDEA method, this prior in-depth conceptual analysis revealed the main objectives underlying each of the indicators. They concern:

- on the one hand, the preservation of natural resources (water, air, soil, biodiversity, landscape and mining resources); and
- on the other hand, social values that are characteristic of a certain degree of socialization and are implicit in sustainable agriculture (ethics, quality, socially-aware practices, etc.).

This method is structured around objectives which are grouped together to form three sustainability scales. Each of these three scales is sub-divided into three or four components (making a total of 10 components) which in turn are made up of a total of 41 indicators.

The objectives of the agro-ecological scale refer to the agronomic principles of integrated agriculture (Viaux, 1999). They must enable good economic efficiency at as low as possible an ecological cost. Those of the socio-territorial sustainability scale refer more to ethics and human development, essential features of sustainable agricultural systems. Lastly, the objectives of the economic sustainability scale specify the essential notions relating to the entrepreneurial function of the farm.

A single objective can contribute to the improvement of several components of sustainability.

Table 1: The sixteen objectives of the IDEA method.

Consistency	Careful management of non-renewable natural resources
Preservation and management of biodiversity	Local development
Soils preservation	Citizenship or socially-aware practices
Preservation and management of water	Human development
Atmosphere preservation	Quality of life
Product quality	Adaptability
Ethics	Employment
Landscapes preservation	Animal well-being

The objective of consistency merits particular attention. While it is not specific to sustainable farming systems, analysis of various recent publications on sustainability in agriculture (Andreoli *et al.*, 2000; Bastianoni *et al.*, 2001; Rigby *et al.*, 2001; Pacini *et al.*, 2003; Cornelissen *et al.*, 2001; Tellarini *et al.*, 2000; Tisdell, 1996) shows that this objective of consistency was not explicitly emphasized, despite the fact that this principle is the very foundation of any analysis of the sustainability of a system. The importance of the objective of consistency was highlighted recently by Cloquell-Ballester who proposed a methodology for validating the performance of indicators based on the work of Bockstaller and Girardin (2003) on indicator validation from three fundamental points of view: conceptual consistency, operational consistency and utility. Conceptual consistency determines the correct relation between the indicator and the measuring object (environmental/socio-territorial, economic). Operational consistency determines the correct definition of the internal operations of the indicator (Cloquell-Ballester *et al*., 2006) which correspond respectively to design validation, output validation and end-use validation.

This explains its high frequency in the IDEA method (Table 1). Indeed, while intensive systems possess very great technical consistency, generally turned towards the search for maximum yield in the short term, they often pollute and waste resources. It is therefore a different value system that pervades sustainable agriculture. This gives rise to *another form of consistency*, more global and more transversal, concerning the farmers not only in their function as agronomists and company chiefs but also on a personal level, as protagonists in society and as citizens.

As well as this, we must make the distinction between technical consistency and consistency in terms of "citizenship." Technical consistency refers to a set of farming practices which, working together, amplify each other and produce effects that are greater than the sum of individual effects. For example, consistent cropping plans, rotations and operational sequences make it possible to combine profitability, quality of production and protection of the environment. As for *consistency in terms of "citizenship,"* this refers to socio-economic behaviour that enhances sustainable agricultural and rural development. It is therefore no longer specific to sustainable farming systems.

Second Stage: Build a matrix combining the target objectives with the indicators used to characterize them

To move from the conceptual framework of the objectives to measuring achievement, the intermediate stage is to propose indicators intended to translate these objectives into measurable criteria. In this phase, it is useful to build a matrix including the objectives and indicators. The matrix of the IDEA method is constructed with 41 indicators providing information on 16 objectives.

Figure 1: The indicators/objectives matrix of the IDEA method.

3 scales, 10 components and 41 indicators	Component	Indicator number	Coherence	Biodiversity	Soil preservation	Water preservation	Atmosphere	Food quality	Ethics	Local development	Landscape preservation	Citizenship	Management of non-renewable resources	Human development	Quality of life	Adaptability	Employment	Animal well-being
			16 objectives															
Agro-ecological scale	Diversity	A1	X	X	X						X							
		A2	X	X	X						X							
		A3		X							X							
		A4	X	X														
		A5	X	X														
	Organization of space	A6	X	X	X						X							
		A7	X	X	X	X					X							
		A8	X		X					X	X		X					
		A9	X	X	X	X					X							X
		A10	X	X							X	X						
		A11	X		X	X									X			
		A12	X	X	X	X		X			X							
	Farming practices	A13	X			X	X	X					X					
		A14				X	X						X		X			
		A15	X	X	X	X	X	X							X			X
		A16						X	X						X			X
		A17		X	X	X							X					
		A18			X	X							X		X			
		A19	X				X						X					
Socio-territorial scale	Quality of the products and land	B1						X		X		X		X				X
		B2	X						X		X			X	X			
		B3									X	X	X		X			
		B4	X						X		X	X			X			
		B5	X						X	X		X		X				
	Employment and services	B6	X							X								
		B7								X		X						
		B8							X	X		X					X	
		B9								X		X		X	X			
		B10								X					X		X	
	Ethics and human development	B11	X						X				X	X				
		B12	X							X				X	X			
		B13	X												X		X	
		B14												X	X			
		B15													X			
Economic scale	Economic viability	C1	X							X					X	X		
		C2	X													X		
	Independence	C3	X												X	X		
		C4	X													X		
	Transferability	C5	X							X		X			X	X	X	
	Efficiency	C6	X			X							X					

Source: Vilain et al., 2003

Third Stage: Set out the initial hypotheses and choices for the construction of the indicators and their calculation method

The question of a hypothesis and method of calculation

Any method based on indicators implies an initial formulation of a hypothesis which will be tested, then the choice of a method of calculation is determined and the determination of reference values made. These reference values or thresholds are necessary when developing a tool to assist in decision-making/action.

In the IDEA method, the initial hypothesis postulates that it is possible to quantify the various components of a farming system by giving them a numerical score and then weighing and aggregating the information obtained to give the farm a score on each of the three scales being used to qualify sustainability: an agro-ecological scale, a socio-territorial scale and an economic scale.

Concerning the calculation method, it is based on a points system with an upper limit. The three sustainability scales are of equal weight and go from 0 to 100 points. All the information is translated into basic sustainability units determining the score allocated to each indicator. Maximum scores are set for each indicator in order to set an upper limit on the total number of sustainability units. The score of a farm on each of the three sustainability scales is the cumulative number of basic sustainability units (or points) awarded for the different indicators in the scale in question. *The higher the score, the more sustainable the farm is considered being on the scale in consideration*.

In the same way, each component is also limited to a ceiling value (generally 33 points). This calculation method allows farms a very large number of possible technical combinations resulting in the same degree of sustainability. Indeed, even though certain principles are common to all sustainable farming systems, we consider that there is not just one single model. The wide variety of contexts and production environments and the diverse production systems and technical combinations encountered mean that there are a very large number of possible ways of making progress. Certain technical or structural weaknesses can therefore be partly made up for by options that are more compatible with the general organization of the production system.

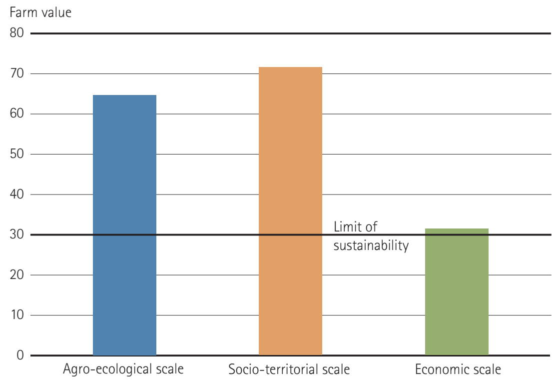
The question of aggregation to give a single global score to qualify sustainability

Once the principle of awarding sustainability points is accepted, two questions are raised: on the one hand, that of the aggregation of these points within a single component and then between the different components of the scale and, on the other, that of aggregation between the three scales of sustainability. From a scientific point of view, this raises issues on two levels:

- on the conceptual level, what is the meaning of a single sustainability score pooling the three scales (dimensions) of sustainable agriculture? The response depends to a large extent on the philosophical debate as to the meaning to be attributed to sustainable agriculture; and
- on the methodological level, how can we go about combining the points within a given component and then within the same scale? The response on this level can be instrumental in developing pertinent methods (simple models, multi-criteria methods, etc.).

These questions are complex by their very nature and worth presenting in their own right. The purpose of this paper, however, is not to answer them on the theoretical level. Thus, regarding the first point, we refer to the debate on the concept of sustainability initiated by Hansen (1996) and, on the latter point, to the various methodological studies of Mitchell *et al*. (1995), Cornelissen *et al*. (2001) and Bockstaller and Girardin (2003) on the aggregation and then validation of composite indicators.

Figure 2: The IDEA rule on attribution of the final farm sustainability score.



Source: Vilain et al., 2003

In the IDEA method, when it comes to the question of global scores aggregating the three scales, the authors allocate the lowest value of the three scales as the final numerical sustainability value, thus applying the rule of key constraints which is called for in the dynamics of ecosystems. Indeed, awarding an all-inclusive, single score would have no real meaning in that it would allow compensation between the results of the three scales (figure 2).

The question of the scale of values in the scoring system

Any scoring system requires the construction of a value scale and a meaning in order to situate the score awarded and therefore characterize the level of sustainability.

In the IDEA method, maximum marks translate the weight attributed to each indicator within the component to which it relates and, consequently, the weight attributed to each field in the sustainability scales in question. The maximum score awarded to each indicator is defined not with the aim of establishing an absolute optimal value, but rather practices, behaviour or levels of results that do not give rise to fundamental remarks concerning the notion of sustainability. Once tests had been conducted, the scoring scales are calibrated to achieve the greatest possible discrimination between farms.

However, for certain indicators, negative scores are allocated, highlighting critical situations in relation to sustainability. For example, the use of phyto-sanitary products of class seven,[2] zero grazing or straw burning cause elementary sustainability points to be lost and can lead to negative scores in the absence of factors to compensate for them.

Fourth Stage: Develop the content of the three scales, organize consistency within each scale and describe the construction of each indicator in detail

In this stage, the respective content of the three sustainability scales (agro-ecological, socio-territorial and economic scales) is formalized and organized to give them a meaning.

In the IDEA method, each sustainability scale is subdivided into three or four components which summarize the major fundamental characteristics of the sustainability diagnostic assessment (Tables 2, 3 and 4). A total of 41 indicators are proposed. Most are composite indicators established on the basis of easily quantifiable magnitudes, but there are also a few cases of more qualitative data.

2 Article 13 of Regulation n°1782/2003 of 29 September 2003 setting out the common rules for the CAP support system, OJEC of 21.10.2003, L 270.

Agro-ecological sustainability scale

This scale analyzes the propensity of the technical system to combine efficient use of the environment and the lowest possible ecological cost. This first scale includes the indicators illustrating the capability of the farms to be more or less autonomous in relation to the use of non-renewable energy and materials and to generate more or less pollution.

Table 2: The indicators in the agro-ecological sustainability scale.

3 components	19 indicators	Maximum values for each indicator and component	
Diversity	Diversity of annual or temporary crops	13	Maximum total of 33 sustainability units
	Diversity of perennial crops	13	
	Diversity of associated vegetation	5	
	Animal diversity	13	
	Enhancement and conservation of genetic heritage	6	
Organization of space	Cropping patterns	10	Maximum total of 33 sustainability units
	Dimension of fields	6	
	Organic matter management	6	
	Ecological buffer zones	12	
	Measures to protect the natural heritage	4	
	Stocking rate	5	
	Fodder area management	3	
Farming practices	Fertilization	10	Maximum total of 34 sustainability units
	Effluent processing	10	
	Pesticides and veterinary products	10	
	Animal well-being	3	
	Soil resource protection	5	
	Water resource protection	4	
	Energy dependence	8	
	Grand total	**100**	

Source: Vilain et al., 2003

The 19 indicators in this scale (Table 2) concern three components which are each of the same importance (33 points): diversity of production, organization of space and farming practices.

Diversity of production takes account of the complementarities and natural regulation processes allowed by farming ecosystems. It is apprehended through five indicators qualifying the diversity of species or crops. However, the interest of a diversified production system can only be expressed if it is designed to make the best possible use of the natural assets of the area and to limit its handicaps and any damage to the environment. These aspects are dealt with by the indicators concerning the organization of space and farming practices.

Socio-territorial sustainability scale

This scale characterizes the integration of the farm within its territory and in society. It seeks to assess the quality of life of the farmer and the weight of the market and non-market services rendered to the territory and to society. In this respect, it allows us to look into issues that go beyond the farm itself.

Table 3: The indicators in the socio-territorial sustainability scale.

3 components	16 indicators	Maximum values for each indicator and component	
Quality of the products and land	Quality of foodstuffs produced	12	Maximum total of 33 sustainability units
	Enhancement of buildings and landscape heritage	7	
	Processing of non-organic waste	6	
	Accessibility of space	4	
	Social involvement	9	
Organization of space	Short trade	5	Maximum total of 33 sustainability units
	Services, multi-activities	5	
	Contribution to employment	11	
	Collective work	9	
	Probable farm sustainability	3	
Ethics and human development	Contribution to world food balance	10	Maximum total of 34 sustainability units
	Training	7	
	Labour intensity	7	
	Quality of life	6	
	Isolation	3	
	Reception, hygiene and safety	6	
	Grand total	100	

Source: Vilain et al., 2003

In practice, it combines and weights practices and behaviour that are easily quantifiable with essentially qualitative elements (architectural quality of buildings, landscape quality of surroundings). Certain indicators like probable farm sustainability, labour intensity, quality of life and the feeling of isolation are determined on the basis of the farmers' declarations. Some indicators concern the family and not the farm itself in the strictest sense, because experience shows the importance of the family-farm link in the sustainability of agricultural systems. Indeed, aside from the purely economic finalities, personal objectives and countless relational links also interfere with the life of the company. The three components of socio-territorial sustainability have the same weight and an upper limit of 33 on a maximum scale of 100.

Certain questions dealt with by the indicators in the socio-territorial scale can only be analyzed through qualitative factors. Quantifiable or observable items can nevertheless be combined with qualitative elements, as long as they have a meaning on the territorial scale. In this respect, the self-evaluation approach as proposed is a pragmatic way of assessing complex phenomena, and has its place in an awareness-raising approach.

Economic sustainability scale

The last scale, in which the indicators result from the technical and financial orientations of the production system, analyzes the economic results looking beyond the short-term and the ups and downs of the economic situation.

Table 4: The indicators in the economic sustainability scale.

3 components	6 indicators	Maximum values for each indicator and component	
Economic viability	Available income per worker compared with the national legal minimum wage Economic specialization rate	20 10	30 units
Independence	Financial autonomy Reliance on direct subsidies from CAP and indirect economic impact of milk and sugar quotas	15 10	25 units
Transferability	Total assets minus lands value by non-salaried worker unit	20	20 units
Efficiency	Operating expenses as a proportion of total production value	25	25 units
	Total		**100**

Source: Vilain et al., 2003

Apprehended through six indicators, this dimension has been studied for longer by agro-economists who make frequent use of a large number of economic and financial management ratios. Evaluation of economic sustainability, however, goes further than the analysis of purely short-term economic performance. In fact, although the sustainability of a farm depends firstly on its economic viability, its economic independence, transferability and efficiency also come into play.

Economic viability characterizes the economic efficiency of the farming systems in the short- and medium-term. This is an essential piece of data which must be relativized in light of the following indicators. *Economic and financial independence* generally guarantee the medium-term future of the farms by making it possible for production systems to adapt more easily to the inevitable changes in public aid, and to have the capacity to adapt the farm through new investments.

Transferability is a factor in analysis of the long-term. Indeed, the sustainability of agricultural systems is also based on their ability to carry on from one generation to the next. In case of succession, the amount of capital required to run and take over can end up leading to the farm being broken up.

The *efficiency of the production process* is used to evaluate the economic efficiency of the inputs used. This item assesses autonomy, that is to say the capacity of the production systems to make optimum use of their own resources, and guarantees their sustainability over the very long term.

One last stage: Analyze the results of surveys, apprehend the limits, validate the indicators

This last stage is presented in the two next parts 3 and 4 of this paper.

3. Presentation of results of different case studies

The following results come from studies over the period 1998–2002 involving tests on French farms representing different cropping systems.

One of the most important results to be underlined is that the sensitivity of the IDEA method is such that it is capable of observing differences in sustainability between production systems as well as within the same production system. We will begin by presenting case studies highlighting the intra-system sensitivity of the method (in the arable crops system in this case) then other studies will be presented to show differences in sustainability observed between several types of production.

3.1 The method can show variability in sustainability between farms with the same production system: An analysis in the arable crops system

■ Variability in all-round sustainability is shown

Sixty-five farms were surveyed in three different arable zones (*Loiret* and north of *Indre et Loire* administrative countries and *Poitou Charentes* region), of which 18 had a livestock unit. The IDEA method revealed very high variability in sustainability scores over the population tested as a whole, as is shown in Figure 3. In this sample, the sustainability scores vary from 25 to 67 and correspond to the lowest score of each farm among those obtained on the three scales (agro-ecological, socio-territorial and economic) (Viaux, 2003).

Figure 3: Sustainability scores of 65 farms surveyed.

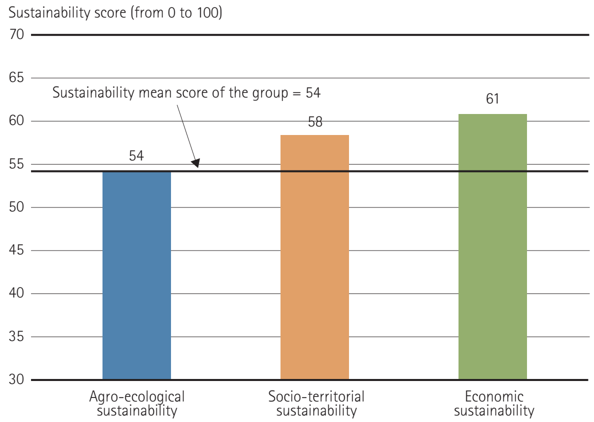
Source: Viaux, 2003

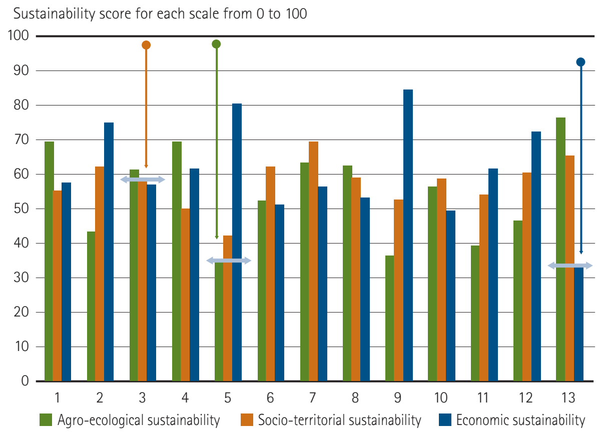
On the basis of these case studies, the sensitivity of the IDEA method was confirmed. This is of great importance in that the method can therefore be used to establish comparisons between farms which are in the same type of production (arable crops in this case) and very similar local contexts (soil and climate).

This sensitivity (in the mathematical sense of the word) endows the method with very particular interest in that it can show differences between farms either on the level of the three scales or their components, or on a particular indicator. The graphs (Figure 4) show two examples of sustainability measurements in groups of farms in the north of Charente Maritime (farms group A) and in the Loiret (central France) for the farms group B.

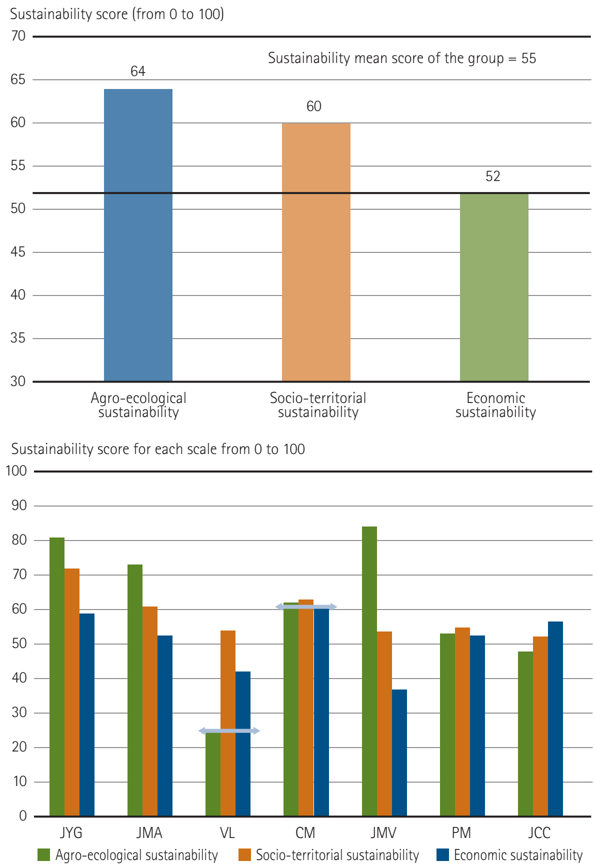
Figure 4: Sustainability of two groups of farms (A and B) and durability scores per scale.

Group A (13 farms in Charente Maritime, France).





Group B (8 farms in Loiret, France).

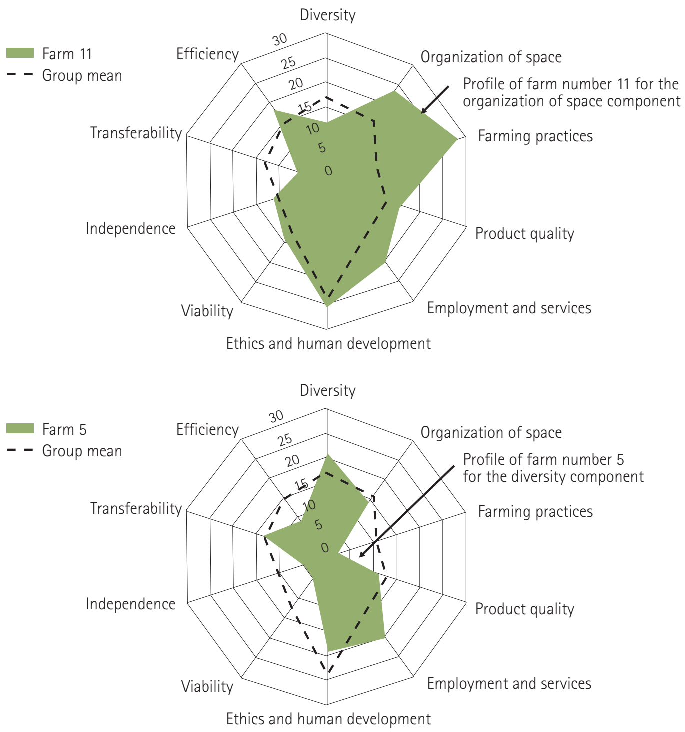


Source: Viaux, 2003

These two cases show that mean sustainability can differ greatly from one group to another, since in group A, it is agro-ecological sustainability that is the limiting factor, while in group B it is economic sustainability. If the results are analyzed for each farm, the same variability is shown within each of the groups, with high sustainability levels (a score of around 60 for farms "3" in group A and "CM" in group B) and low levels (farms "5" and "VL" respectively) being identified in each. The factor limiting sustainability may be agro-ecology (farms "5" and "VL"), economy (farms "13" and "JMV") and, more rarely, socio-territorial aspects (Viaux, 2003).

Moreover, each farm has a profile that can be viewed, for example, in the form of a radar chart (Figure 5), and the fact that no two farms resemble each other proves that the IDEA method gives a fairly precise reflection of differences in the situation and management of the farms. Conducting an IDEA diagnosis with a group of farmers from the same small farming region can prove to be highly profitable. We will take the example of a group of farmers from the Aunis area (Charente Maritime). The two graphs in Figure 5 present an overview of the 10 IDEA components on two farms (numbered 5 and 11). It can be observed that the IDEA method is sufficiently sensitive to highlight large differences in sustainability between farmers in the same small farming region with the same production system.

Figure 5: Example of sustainability assessment of farms 11 and 5 in comparison with a group of crop farmers (in the Aunis area, Charente Maritime, France).



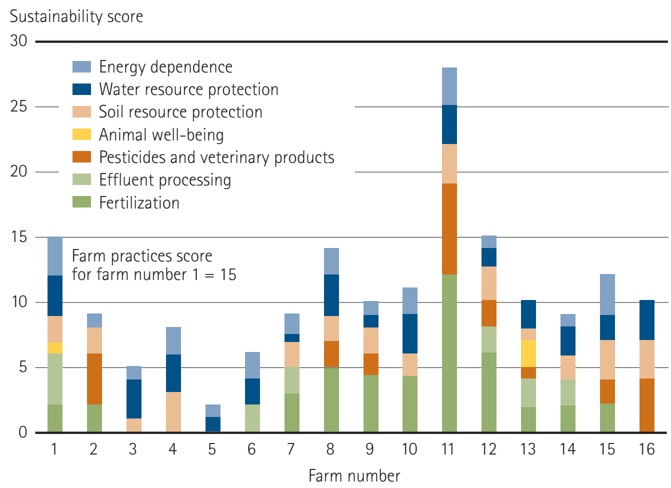
Source: Viaux, 2003

Farm 5 has a low sustainability area and, apart from the transferability and social items, all the other points are at levels lower than those of the group. Farm 11, in contrast, has agro-ecological practices (especially concerning space and farming practices) and economic results that are higher than the average for the group. We should note that this comparison within a group enables us to situate each farmer not in relation to an absolute sustainability objective, but in relation to what can be done in a given setting.

- The method also shows the diversity of farming practices for a given sustainability component.

Lastly, if we look in detail at the farming practices of the group as a whole, we can observe widely varying situations from one farm to another (Figure 6). This can appear surprising for farmers who have the same sources of information and work in the same soil and climate conditions. These differences between farming practices make it possible to identify one or several farms that are of interest in terms of sustainability and to get the farmers to discuss their own results among themselves with a view to getting them to make progress towards greater sustainability.

Figure 6: Differences in farming practices between cereals farms within the same small farming region (example: Aunis area in Poitou Charentes, France).



Source: Viaux, 2003

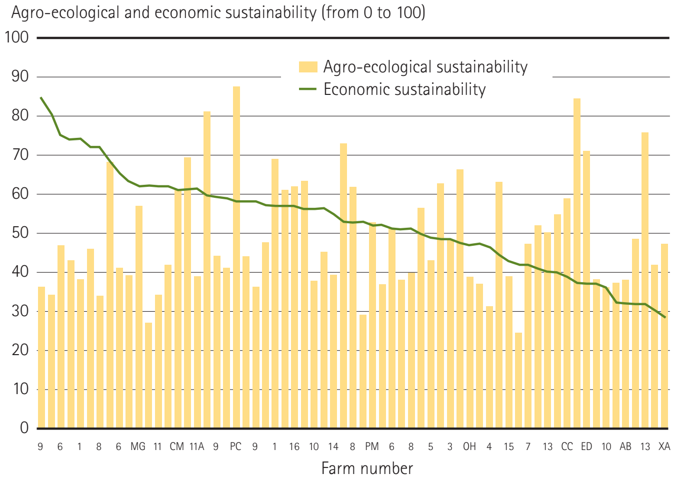
As presented in the second part, the higher the score, the more sustainable the farm is considered as being in terms of the scale in consideration.

Figure 6 shows that farmers have fertilization practices with scores varying between zero and 12 (extreme values for this indicator) and pesticide practices scoring between zero and seven. Detailed analysis of this data involves searching for the reasons for differences in the results, seeking to understand what technical reasoning (or what behaviour) led to this result and thereby identifying possible ways of progressing. Such an analysis can be made indicator by indicator and can identify one or several particularly interesting farms. For example, the results of farm 11 show that its farming practices are an excellent example of an integrated arable farming system: long rotation, weed control by a combination of mechanical and chemical means, limited used of pesticides and rational use of fertilizers etc.

- The method challenges certain notions regarding the cost of protecting the environment

Viaux *et al*. (2003) showed that by grouping together a large amount of farming data, it is possible to clarify certain general ideas on sustainability. We have seen, in certain graphs, that there seems to be a form of opposition between agro-ecological sustainability and economic sustainability, such as on farms two, five and nine in the St. Jean d'Angély group (Figure 4). In fact, this point is often raised as evidence that sustainability is utopian. In fact, if all the data from the farms is analyzed closely, it can be seen that there is no correlation between these two sustainability scales. This is highlighted in Figure 7, in which the farms are classified in decreasing order of economic sustainability. Agro-ecological and economic sustainability are independent of each other. It is therefore possible to achieve good economic sustainability while preserving the environment. This observation is backed up by analysis of the relation between the C1 economic viability indicator and the all-round score on the agro-ecological sustainability scale, which again shows that there is no relation between the two. This type of analysis is also capable of identifying the farmers who succeed in reconciling these three aspects of sustainability and who can serve as pedagogical examples for group work.

Figure 7: Analysis of the relations between economic sustainability and agro-ecological sustainability (65 farms).



Source: Viaux, 2003

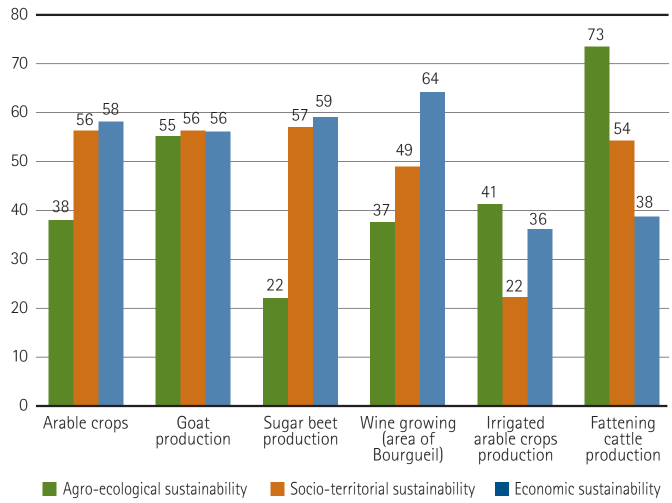
In this case studies, good economic results and good agro-ecological results are not incompatible in a cereal farming system (Viaux, 2003).

3.2. The method can show variability between different types of farming present in a territory

We have seen that IDEA is a tool that can help farmers progress towards sustainability. The many case studies conducted over the period 1999–2003 show that the IDEA method is also a relevant and highly interesting tool to appraise sustainability in different farming systems and to allow comparisons between the different types of farming present in a territory.

As an example of this, six case studies conducted on different farming systems in the Centre region (Viaux, 2000) are presented below (Figure 8).

Figure 8: Sustainability score per scale for six different types of agriculture.



Source: Viaux, 2000 (results with 1st IDEA edition)

In this example, the IDEA method highlights differences in sustainability within the same sustainability scale. For example, the two livestock rearing farming systems (goat production and fattening cattle production) have a higher agro-ecological sustainability score than the four other kinds of production presented. It is the quality wine production farming system, however, that boasts the highest economic sustainability score.

It can thus be shown that, quite generally, arable crop systems have good economic sustainability and quite low agro-ecological sustainability, while cattle rearing systems tend to be the opposite. These remarks will surprise nobody, given that cereals systems consume much greater quantities of inputs (fertilizers, pesticides, seeds, etc.) than a cattle breeding system on grass that has a less negative impact on the environment. The interest of IDEA is that it measures these differences objectively. The authors would like to point out, however, that the scores associated with these case studies in no way represent a mean regional or national value of the systems analyzed in these case studies.

This figure illustrates the suitability of the IDEA method as a high-quality, easy-to-use tool to evaluate European rural development policies in particular. For the main farming systems, the IDEA method can measure the progress made towards sustainability over time by a farm that has signed a Sustainable Agriculture Contract[3].

The IDEA method can also be used as an analysis tool by scientists and decision-makers to compare sustainability between different types of farming or to compare the sustainability of production systems such as conventional and organic farming systems (Viaux, 2003; Del'Homme and Pradel, 2005).

At least, the methodological work conducted over the period 2000–2003 gave rise to a second version of the IDEA method (Vilain *et al*., 2003) to take account of certain specialized crops (horticulture, market gardening, arboriculture, wine growing). Authors note that on the basis of tests on farms and feedback, it must be recognized today that the IDEA method indicators have difficulty measuring the agro-ecological sustainability of farms specialized in horticulture or market gardening. The specific nature of farming practices in these two types of farming system is at the moment not taken into account sufficiently in the current indicators of the method.

3.3. Implementation method and interest of discussion with groups of farmers

This method can be implemented by a farmer under the supervision of an advisory officer. It can also be conducted by a farm advisor, on condition that the farmer collects the information beforehand (accounts, field pattern, etc.) and that the information is processed by the farm advisor. The tests conducted show that most of the values of the indicators can be determined by the researcher in the presence of the farmer with a half day of work once the necessary documents have been gathered together.

Because of the construction of these indicators, different combinations of basic sustainability units from one farm to the next can result in the same score, thus enabling us to compare farms with radically differing patterns or practices. The interest of this resides in the fact that it allows individual monitoring over time while making it possible to conduct work in groups to compare farms with others and see how each of them can progress towards sustainability. It can also be of interest to have the whole group of farmers visit farms with interesting sustainability practices. This provides an opportunity to go into the details of the whole production system and possibly identify the skills deployed to master the most sustainable techniques.

3 The Sustainable Agriculture Contract is the French contract to subscribe an agri-environmental measure.

4. Discussion on the IDEA method taking account of tests from case studies

The indicator aggregation system

The authors resolved, for reasons of pragmatism, to add together the values of the different indicators, aware as they were of the fact that this approach implies compensation between the different components. In this way, favourable practices will offset practices with a harmful effect on such or such another component. This does admittedly constitute a real weakness for those focusing on the sole arithmetical value of the diagnosis. On the other hand, this addition does have a real meaning within the same component. For example, low animal diversity can indeed be partially compensated for by greater diversity of annual and permanent crops.

The scoring scales and weighting

The most delicate aspects concern the scoring scales associated with each indicator and the weighting attributed to each indicator. This work was conducted by a multi-disciplinary group of French experts comprising about 30 people. Scoring and weighting were established on the basis of a consensus starting out with the macro-issues (the scales), then moving down to the level of the components and finally to the indicators themselves. The lowest possible score associated with most of the indicators is zero. This score can mean quite simply that the farm is not concerned by the indicator. In this way, the animal diversity or endangered breed indicators will concern only livestock breeding, while the indicators in the socio-territorial or economic scales concern all the farms. For farms that are concerned by the indicator, a score of zero does not necessarily mean an insurmountable handicap or obstacle to sustainability, but shows that the farm has room for progress.

The pertinence of the model

The system of indicators proposed does not claim to be untouchable or to establish a model of sustainability that must never be changed. It has been drawn up using the expertise of a multi-disciplinary team working as a group and with the help of a large number of trips in the field. It has been tested for five years with many farmers, is the result of a consensus and seeks to give practical content to the notion of sustainability.

For example, the 16 indicators in the socio-territorial scale do not constitute a definitive, exhaustive list of the social and territorial dimension of agriculture. On the one hand, there are no indicators for the territorial function (services rendered to the territory and society) or for the social dimension of farming operations (*quality* of work, hygiene and safety, etc.). The absence of simple, pertinent indicators capable of assessing these complex notions has led us to leave them out for the moment. On the other hand, society is changing, with new needs, new demands and new regulatory or ethical requirements. Given that the agricultural world is connected with the rest of society, what was impossible yesterday can become possible tomorrow and the socio-territorial scale will necessarily evolve over time.

Validation of the hypotheses

If we take an epistemological view such as that proposed by Friedman (1953), a hypothesis does not need to be realistic. It must be judged on the basis of the forecasts that the model makes possible. However, seeking to validate the realism of the hypotheses of a sustainability model does pose the question of whether it is possible to validate it scientifically, as this concept of sustainability involves hypotheses taken from the experimental sciences but also from the social and human sciences.

Validation of the results of the indicators

Validation of the indicators constitutes the last stage in the construction of the IDEA method. An indicator is validated if, on the one hand, it is scientifically sound and, on the other, it meets the objectives for which it was created. In the first case, it is a question of "design" validation, notably through the criticism of scientific articles by peers. In the second case, the indicator is validated if it acquires use-value, serving as a diagnosis tool and actually being used as a tool to assist in decision-making (Bockstaller and Girardin, 2003).

Given their multi-criteria character, many of the IDEA indicators cannot be validated by comparing them with field data. They can only be compared with the results of models because there are no complete models for systems as complex as farms. However, the values of certain IDEA indicators can be compared with the values of other indicators. For example, the pesticide pollution pressure indicator was compared with the "I-PHY" indicator developed by the INRA in Nancy-Colmar (van der Werf and Zimmer, 1997). Likewise, the energy dependence indicator was compared with the results of the energy approach developed by the ADEME and the INRA Nancy-Colmar "energy" indicator (Pervanchon *et al*., 2004). For other indicators, experts other than the authors were asked to give an opinion on the calculated values and scores.

Certain difficulties relating to scoring and weighting were attenuated thanks to the tests that were conducted. These tests also provided an opportunity to check that the method allowed fruitful exchanges with the farmer or between farmers, thus leading to the experimental validation of its use-value. It fulfils its purpose if it prepares farmers to develop a better understanding of the mechanisms they will have to implement and to identify more clearly the factors on which they will be able to act if they should decide to undertake the switch towards sustainable agriculture.

The expected progress concerns primarily the socio-territorial indicators which are an innovative approach for which there are currently few references, and the analysis of the relations between these indicators and the other indicators. There is the question, for example, of a more comprehensive approach to the family as a collective group, the employment created locally by farming activity, hygiene and safety at work or even the topical issues of food safety. Regarding economic sustainability, the small number of indicators is explained by an intentional choice to limit ourselves to simple indicators expressing primarily the economic conditions necessary for the medium and long-term survival of the farms. This was considered as being guided in the long term by agro-ecological and social conditions. But it is obvious that the choice of practices that are respectful of the environment or the development of synergies on the scale of the territory have consequences in economic terms for the farms.

Conclusion, prospects for use and for related research

IDEA method is now accepted as being a tool that is easy to use. It provides a simple, faithful diagnosis tool that is sensitive and operational and gives a global analysis of the farming system.

These first results have been completed by studies conducted by some French agricultural organizations which wish to appropriate the IDEA method by testing it and to hold debates on sustainable agriculture on the basis of this awareness-raising and training tool. Moreover, French secondary and higher agricultural education now use this tool in pedagogical training to explain the concept of sustainable agriculture to their students and test it with farmers.

It allows appropriation of the concept of sustainable agriculture, and gives farmers suggestions for possible ways of modifying the management of their production system.

Used systematically, the method can answer certain questions on the feasibility of sustainable agriculture. Analysis of the results for the groups of farms mentioned above, for instance, shows that there is no relation between the three sustainability scales. We notice that agro-ecological sustainability is independent of economical sustainability, and vice versa. It is therefore possible to have good economic sustainability while preserving the quality of the environment. A more in-depth analysis shows that there is no relationship between economic viability (which is an indicator of farmer income) and agro-economic sustainability.

Today, this method can make a useful contribution for the implementation of Article 13 of the new CAP which specifies the new advisory system.[4] In fact, as of 2007, each Member State must be able to offer a system of agricultural advice to farmers who request it. At present, the content of this advice has not been defined on the European level and the tools needed to provide it are under discussion. The question of a minimum level of harmonization of the content of such counselling is therefore raised on the European level.

This method could also contribute to implementation of Article 69 of CAP-reform by helping to characterize the types of agriculture likely to benefit from additional financial support. The new system authorized by Article 69 allows Member States to keep up to 10 per cent of the amount of pillar one aid to support types of agriculture that favour the environment (but not defined in the regulation at the moment).

Thus, the extension of the IDEA method to a European scale could make it possible to meet these new needs. The research project associated with this objective could concern, in particular:

- the inclusion of all the main crops present in the European Union in the IDEA method;
- the specific points to be added to take better account of the links between the specific issues of a territory and its farms;
- the question of adapting the method to the specific aspects of the farms in certain new EU Member States; and

4 Article 13 of Regulation n°1782/2003 of 29 September 2003 setting out the common rules for the CAP support system, OJEC of 21.10.2003, L 270.

- the calculation of indicators with data from national databanks (like FADN[5]) and not from individual farmer surveys. This work would create the possibility, in particular, of evaluating the new data required and the *ad hoc* processing to be applied so that it could measure, in time, the contribution of farms to the new expectations of civil society (multi-functionality, environmental services).

As well as this, the IDEA method can also not only be a most interesting assessment tool to guide farmers who are conducting a farm audit prior to committing to agri-environmental measures (called Sustainable Management Contract in France) but also a tool for monitoring and assessing measures in rural development regulations. In the latter case, complementary research work would seem necessary to measure how the indicators in the method fit in with the main measures in rural development regulations.

Finally, the new rules of cross compliance on support for agriculture (CAP, 2003) will necessarily raise questions on how to go about increasing support for farms in line with the new expectations of consumers and citizens concerning the quality of products and the environment. As for the recent agreements at the World Trade Organization (2005), there are questions about the contents of the "green box" and types of agriculture which will still be supported after 2014 (deadline for next agreement regarding the future CAP). This is certain to become one of the stakes in international negotiations on agriculture. The European Union will be called upon to prove the link between the level of public aid, the multifunctional character of farms and sustainable agriculture. If the large-scale application of a reorientation of subsidies is to be possible, first the practical problems must be resolved relating to the definition of the criteria corresponding to these objectives, criteria which must be legible, simple and effective to use in the field.

The latest prospective research using the IDEA method aimed at the assessment of the level of sustainability for French farming systems by major production systems and by regions. It was based on the transposition or adaptation of the sustainability indicators in the IDEA method in order to analyze the sustainability of the principal French type of farming, no longer the sustainability of individual farms only. This study combines the set of indicators of the IDEA method with information from two additional databases (the FADN[6] and the farming census) (Girardin

5 FADN or Farm Accounting Data Network.

6 Farm Accounting Data Network.

et al., 2004). This preliminary work could be extended to other European countries where the FADN exists (all the 15 countries of the former EU). For the present authors, the INFASA international Symposium provided a great opportunity to propose that other research teams work on this theme, potentially as part of research work within the next 7th Research Framework Programme currently being prepared by the Community.

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When Farmers Integrate Sustainable Development in their Strategy Thank a Tree: The Sustainable Farm Tree®

Frank Pervanchon

F. PERVANCHON – Association Trame, 6 rue de La Rochefoucauld, 75009 Paris, France.

Abstract

Trame, a French national federation of farmers' and farm employees' associations, has assessed a methodology to help farmers take into account sustainable development in their decision-making processes: the Sustainable Farm Tree®. This methodology is developed for and by farmers—meaning that farmers themselves improve the tool as utilization goes along.

It is based on a set of around 60 qualitative questions corresponding to the dimensions of sustainable development: economy, transmission of capital and knowledge, social aspects and environment. A farmer answers each question considering their own point of view: there is no standard or threshold, and some indicators are given to help farmers answer these questions, if necessary.

All answers are symbolized by the leaves of a tree, while branches correspond to the sustainable development dimensions. If the answer is: "no, this aspect is a problem for me, I have to improve it," the leaf is coloured in black. If the answer is: "yes, it is a good point for me," the leaf is coloured according to the branch (green, yellow, blue and orange). If the question has no meaning, considering the farm and its context, the leaf remains white. At the end, each farmer has a global image of the sustainability of his farm according to the colour of the tree.

Then, farmers have to think of ways to improve their tree: therefore they launch projects and they raise business plans with the guidance of the image of the tree.

The Sustainable Farm Tree® can be used by a farmer alone, but it reveals all its abilities in groups of farmers: the farmers argue, discuss answers together, and usually take into account the remarks of their "peers," even in cases where expert advice might otherwise be rejected. Moreover, the projects and business plans can be discussed collectively, which is a source of mutual enrichment.

Keywords: Sustainable development symbolization, auto-diagnostic, Sustainable Farm Tree.

Introduction

Trame (meaning network in English), is a federation of four non profit associations in France which aim to share means and competences for the animation of agricultural networks. It is also a resource centre for sustainable development applied to farms. Its major domains of activity include: renewable energies, farmer strategy, sustainability assessment, compost on farm, territorial development, work organization, services on farm, communication and agro-equipment. Trame acts for an agriculture which contributes to sustainable development.

Principles of the Sustainable Farm Tree® of Trame

The aim of the Sustainable Farm Tree® of Trame is to help farmers build a business project on farms, according to sustainable development stakes. The tree is an aid-decision tool and not a way to control farmers: it helps farmers evolve and not to be condemned.

This methodology is created *for and with* French farmers.

It can be used by farmers alone, but a collective use is preferable, for instance in groups under training, because it allows a mutual enrichment through crossed farmers' points of view over each farm system and context.

History of Sustainable Farm Tree®

The Sustainable Farm Tree® is a methodology which is continuously improved as farmers continue to utilize it.

The story begins in 1997, when a farmer association of the Oise department (North Paris, France) wanted to make its members aware of the stakes of sustainable development. At that time, no tool or methodology existed in France. Therefore, farmers decided to create such a tool. Workshops with farmers and engineers were then launched.

The first version of the Tree appears in 1999: four branches corresponding to four dimensions of sustainable development (reproducibility-environment, viability-economy, liveability-social aspects and transmissibility-transmission between generations of capital and knowledge). At that time, the image of the tree is only for farmers' awareness about sustainability.

It isn't sufficient. Farmers want a tool to help them to make decisions according to sustainability stakes. In 2000, the Tree is improved: the tree is redrawn and accompanied by a set of questions collected in a notebook. Each question corresponds to one leaf of the tree. And the colour of the leaf varies according to the answers to the questions.

Year after year, the questions are improved or modified according to the feed-back of users.

A convention is signed between Trame and the users of the Sustainable Farm Tree: each year, Trame sends out a new version of the tree to users, and users send their comments and improvement requests. The possibility of a one-day meeting for the exchange of users' practices is offered annually.

One stake is to consider the systemic approach implied by sustainability: it is not possible to consider separately economy, social aspects and environment because these dimensions interact. Therefore, in 2006, the tree is redrawn. This version is presented to the INFASA seminar.

How does the Sustainable Farm Tree® work?

The Sustainable Farm Tree® is an aid-decision tool based on a qualitative approach, and, if possible, a collective use.

First step: to clarify one's farm position by auto-evaluation

Each farmer in a group under training for instance, has a listing of around 60 questions about the four dimensions of sustainable development: viability branch (economical aspects: subsidies dependency, income, etc.), transmissibility branch (transmission between generations of capital and knowledge), liveability branch (social aspects: time for holidays, neighbourhood, commitment in associations, etc.) and reproducibility branch (environmental aspects: respect of air, water, landscape, old buildings, etc.).

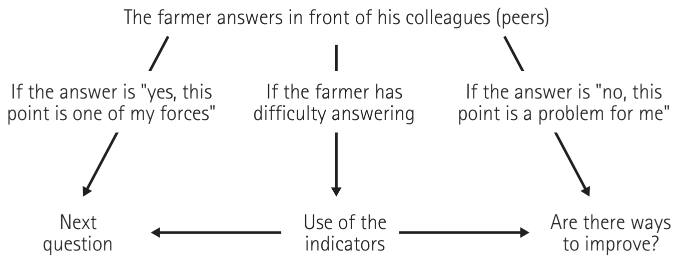
One by one, each farmer answers each question considering their own point of view and they give the answer to the group of colleagues. For instance, to the question: "do I sort out my wastes?" (reproducibility branch) a farmer answers: "I do not sort out my wastes, and it is not a problem for me." The group reacts to the answer: "in my village, it is compulsory. Have you checked for your area?" Or: "in my place, wastes are collected by a firm to be recycled, I am sure it is possible for you to do so." Therefore, the farmer argues, discusses and usually takes into account the remarks of "peers," where expert advice would be rejected. It is a way for farmers to find ways to improve the sustainability of their practices.

Indicators are proposed to farmers when they have difficulties answering a question (for instance, if soil in winter with green cover < 20 per cent of the total surface area, it is suggested to make sure that erosion is under control on the farm). The use of indicators is neither systematic nor compulsory: farmers can ignore them).

It means that the Sustainable Farm Tree® is based on auto-evaluation, the glance of peers being the way to settle limits and thresholds. The group is the guarantor of the consistency of the answers of each farmer.

It is a way to make farmers responsible and autonomous.

Figure 1: Process of decision to answer a question of the Sustainable Farm Tree®.



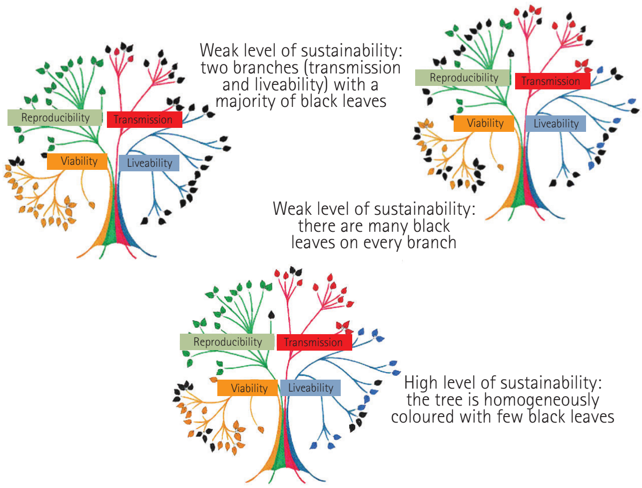
The colouration of the Sustainable Farm Tree® presents a global image of the farm

After having answered each question, farmers are invited to synthesize their answers by colouring the leaves of the Sustainable Farm Tree®.

Each question of the farmer notebook corresponds to at least one uncoloured leaf of the tree. For instance, "do I sort out my wastes?" corresponds to one leaf on the reproducibility branch (environmental aspect); whereas "do I use renewable energy sources" corresponds to two different leaves of the tree: one for the branch "reproducibility" and one for the branch "viability," because energy management on farm has environmental and economical impacts.

The leaves are coloured by farmers according to their answers. If the farmer is satisfied with an answer, then the farmer colours the leaf, (one colour for each branch); if the farmer is not satisfied, then the leaf is blackened. Therefore, an image of the farm and its context is obtained. The colour of the tree provides information on the contribution of the farmer to sustainable development (see Figure 2).

Figure 2: Three extreme cases representing farm contributions to sustainable development.



The settlement of projects and business plans

The images produced using the tree are not sufficient for farmers: as managers, they need to launch projects and anticipate the future.

The tree helps farmers to identify weak and strong facets. Then, farmers have to develop strategies to reduce the dangers threatening the farm and lean on their abilities and resources. The tree is also a way for farmers to think about aspects they usually neglect because they are too concentrated on production (pollution of air, contact with neighbours, urban development, new services, etc.). The tree also helps them to express their difficulties and their successes.

Therefore, the most interesting part of the work is then to help farmers define their strategy and settle their business plan. It means that the tree is a part of a long process.

A modular approach

The tree can be used in training sessions for farmers, alone, or in groups. It can be useful for a quick and pedagogic sustainability diagnosis of farms.

It is possible also for farmers to focus on certain aspects pointed out by the tree. For instance, an energetic balance or a nitrogen balance can be proposed to farmers in order to complement their use of the Sustainable Farm Tree®. This can be done in groups or for single cases. The help of a technician is necessary to transfer the methodology to farmers.

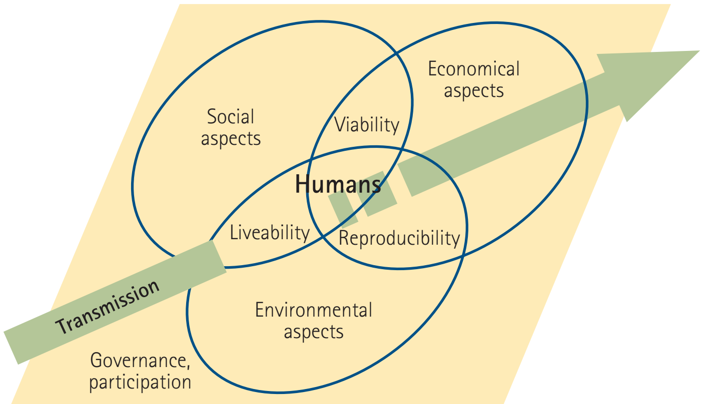
Also, it can be used to identify common objectives in a group of farmers (in an association for instance).

Nevertheless, the most interesting use is the help the tree provides in settling a farm management strategy with the collective input of a farmer's peers.

Towards a new presentation of the Sustainable Farm Tree®

One stake in the sustainable development question includes considering the interaction between its major dimensions: economy, social aspects, and environment and governance, and transmission to other generations (see Figure 3).

Figure 3: Interaction representation of the dimensions of sustainable development.

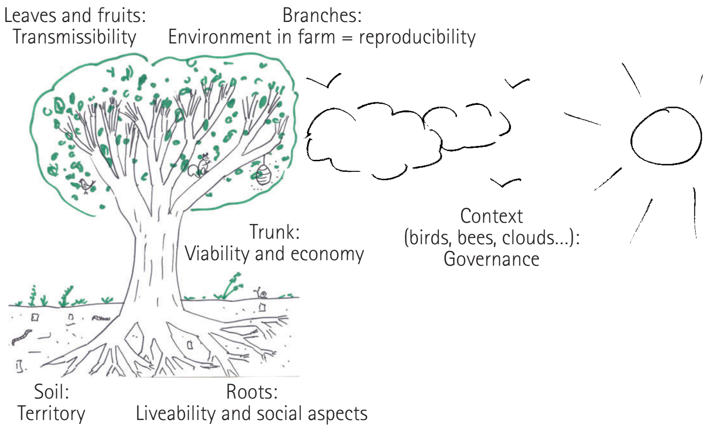


Therefore, the Sustainable Farm Tree® was redrawn recently (see Figure 4). The very recent results are presented here.

Explanation of the new Tree version:

- for farmers, economical aspects are very important. Without income for instance, the farm dies and the farmer has to change jobs! The new version puts economy in the trunk of the Tree: it symbolizes the fact that economy is a pillar for farmers;
- the liveability and social aspects in roots shows that not only family, but also social contacts, exchanges and discussions with local or national partners bring life ("sap") to the farm ("tree"). Without human contacts, the farmers may die (the suicide rate for farmers is very high in France);
- environment is in the branches. It symbolizes what gives the farm its shape and what is seen from outside;
- transmission is the fruits and leaves (what is collected, and what will make other trees); and
- the territory is the soil, (from where the tree pumps its water and to where the fruits and leaves, or organic matter, returns).

Figure 4: New representation of the Sustainable Farm Tree®.



The way to use the Sustainable Farm Tree® remains the same. Around 60 questions are still associated with each part of the tree. But this time, each question corresponds to one organ of the tree (roots for questions about social aspects, leaves for environmental aspects, parts of the trunk for economical aspects), and some are completed for the territory.

The advantages of this new presentation include:

- more rigorous definition of sustainable development;
- visualization of the systemic approach of sustainable development; and
- more coherent symbolization relative to farmers' points of view (e.g., economy is shown as a pillar for farmer).

Farmers are managers: They need their own indicators

Indicators for sustainable development are very necessary for political decisions at the supra-national, national or regional scale.

The Gross Domestic Product (GDP) has been the most-used indicator in the last 40 years used to settle, check and compare politics. Its limits are now underlined: indicators for human welfare, environmental respect, share of goods (between South and North countries for instance), etc. are necessary to balance the NGP indicator and throw light on the contribution of societies to sustainable development. The aim is to complement NGP with indicators that take into account long-term and irreversibility risks. The development of such indicators is a major issue concerning scientists, politicians, NGO, etc. Once the indicators are established, societies will accept them and use them as they do the GDP. Of course, the more numerous the implied stakeholders, the higher the social acceptance (and use). Therefore, indicators for sustainable development applied to agriculture at the regional, national or supra-national level, should be developed with the participation of representative farmers.

At firm- or farm-scale, the stake is the same: managers need to anticipate future risks and adapt their strategies according to the evolution of the local and global context (for instance ecologist pressures, new needs of consumers, etc.). What is different is the way indicators are developed: managers need their own indicators, adapted to their own firm (or farm). Therefore, indicators for firm (or farm) have to be developed by managers themselves. The need is not the indicators themselves but the way to develop adapted and adaptable indicators for each firm or farm.

Indicators for firms or farms which are not developed with (or by) managers often represent a means of control (to ensure respect for the law, for instance), or a means to gather information. As such, they are scarcely efficient in terms of developing a strategy and business plan.

On the basis of their natural skills and feelings and/or long-term experiments, managers need methods and frames to help them make decisions and elaborate indicators that are appropriate for their firm (or farm). Therefore, indicators at firm- (or farm-) scale are useful if they are developed with managers and not prescribed from above in a top-down manner.

RISE: A Tool for Improving Sustainability in Agriculture

A case study with tea farms in southern India

Fritz J. Häni, Andreas Stämpfli, Tobias Gerber, Hans Porsche, Christian Thalmann, Christoph Studer

F. HÄNI – Plant Protection and Agroecology, RISE-Team, Swiss College of Agriculture (SHL), Bern University of Applied Sciences, Länggasse 85, CH-3052 Zollikofen.

A. STÄMPFLI – RISE-Team, SHL.

T. GERBER – RISE-Team, SHL.

H. PORSCHE – RISE-Team, SHL.

C. THALMANN – RISE-Team, SHL.

C. STUDER – Tropical Plant Production and Natural Resources Management, RISE-Team, SHL.

Abstract

Based on the assessment tool RISE (Response-Inducing Sustainability Evaluation) a case study was conducted in the district of Nilgiris, Tamil Nadu, India to highlight potentials, critical deficiencies and possible risks to the prevailing tea production system. The RISE analysis depicts its results on twelve indicators that are calculated from more than 60 parameters, covering ecological, economic and social aspects of sustainability. The study was conducted upon the request of a tea processor on 13 tea growing farms with three to 63 hectares. Some 500 tea growers are producing tea leaves for this tea processor who has a particular interest in knowing whether higher quantities of tea can be produced without compromising ecological and social performance.

To improve the ecological situation on the assessed farms, intervention points were identified in the domains of pest management, nutrient management and biodiversity. Employment opportunities in tea plantations are important for the local population, but salaries of employees, especially those of the tea-plucking women, are most unsatisfactory and have to be increased at least to the minimum existence income (allowing for a life of dignity). The RISE analysis also determined that working conditions should be improved. Such improvements are not only important for the employees but are also of high relevance to the processor in terms of creating a more stable social and economic basis for the business of tea production and processing.

Possibilities do exist to increase tea production and may be achieved by a rational use of fertilizers and pesticides, and by realizing more balanced production throughout the year through irrigation. Raised awareness and appropriate training in good farming practices as well as a more detailed study on possible effects of increasing water withdrawal for irrigation have to ensure, however, that overall sustainability will not be compromised. The RISE analysis showed that yield increases—subject to some restrictions—seem to be possible without negative effects on ecological aspects. Increased productivity may lead to a win-win situation for processors, farmers and employees if more regular and higher incomes are used first to tackle key deficiencies. To guarantee this, a dialogue with the farmers, employees and all involved stakeholders is of paramount importance, and RISE may serve as a key tool for such a dialogue by visualizing the holistic performance of farms.

Overall, the project underlined the practical flexibility of RISE as a holistic, comprehensive and worldwide applicable tool by generating valu-

able information relevant for the managerial decisions of Indian tea producers and processors as well as stakeholders like employees, consumers and the general public alike.

Keywords: Sustainable agriculture, holistic sustainability assessment, sustainability assessment tool, case study on sustainability, sustainable tea production, India, Tamil Nadu, RISE.

Background

The liberalization and globalization of markets exert great pressure on economic aspects of agricultural production by causing generally decreasing and highly volatile commodity prices, which render many farms and even entire sectors unprofitable (Worldwatch Institute, 2003). The financial pressure on salaries (World Bank, 2003) and expected returns on investment can lead to social and ecological dumping. This may result in discrimination, child labour and failure to provide necessities like potable water, hygiene or protection from hazardous substances. This may also trigger the loss of biodiversity, soil degradation, or the contamination of soil, water and air (WWF, 2002; Baratta, 2004).

In this context, it is important that the sustainability of agricultural production can be assessed and monitored in all three dimensions (ecologically, economically and socio-culturally). A simple and inexpensive but still holistic management tool that allows for the pinpointing of potential measures to improve the situation and initiate a response against potential risks and bottlenecks in agricultural systems is, therefore, of great value for farm managers and other relevant entities.

With this objective the Response-Inducing Sustainability Evaluation (RISE) has been developed at the Swiss College of Agriculture (Häni *et al*., 2002, 2003a, 2003b; Studer *et al*., 2006) in cooperation with public and private entities.

RISE basics

The assessment tool RISE (Response-Inducing Sustainability Evaluation) can be used globally for the analysis and comparison of all kinds of farms and production systems. In the development of the tool, emphasis was placed on simplicity and meaningful outputs. A balance between the straightforwardness of the analysis, the complexity of the reality and the transparency of the results shall make the output comprehensible for a wider public. The application of RISE in Armenia, Brazil, Columbia, Canada, China, India, Ivory Coast, Kenya, Mongolia, Poland, Russia, Switzerland and the Ukraine, allows RISE to be adapted and improved on a continuous basis. The establishment of national and regional "RISE-hubs" (competence centres), which are linked in an open RISE platform, allow for locally adapted interpretations of the RISE results and proposals for appropriate measures. However, the tool as such is not locally adapted; only key values like, for example, minimum salary are determined locally (cf., chapters "RISE Methodology" and "Discussion"). RISE-hubs also promote the use of RISE and contribute to the further development of the model and its database. For specific local and detailed management questions additional more specific tools may be used.

The most important goal for RISE is a contribution to the holistic improvement of sustainability in agricultural production. Strengths and potentials regarding sustainable production must be secured and strengthened while weaknesses eliminated. Deficits pinpointed in RISE assessments shall be tackled with effective measures at the farm level as well as by contributing to more favourable (enabling) framework conditions. In addition, the use of the tool aims at initiating a constructive dialogue among producers, processors and consumers to spread the philosophy of sustainable production. This shall lead to a change of mindset and increase the awareness that more sustainable production will benefit all the relevant stakeholders along the supply chain.

RISE, as a management tool, is primarily focused on the requirements of farmers and farm managers. It provides an instrument to visualize strengths and potentials (providing a testimonial), but also to identify weaknesses (need for action) regarding the sustainability of the farmer's specific production practices. Since RISE does not provide specific recipes and solutions it is recommended that a well-trained agricultural consultant is involved in the analysis and discussion of the sustainability evaluation.

For a holistic monitoring of the farm development, repeated RISE evaluations are needed. These are particularly useful to assess the impact of measures implemented to improve the situation (success control). To assist in planning for improvements, different scenarios can be evaluated with RISE.

By evaluating groups of farms, RISE facilitates comparison/benchmarking with peers and the identification of framework conditions particularly conducive to, or unfavourable for sustainable production. This may be particularly attractive for political entities, the producer, trade or label organizations, the processing industry and retailers. It is a unique feature of RISE that its application as a sustainability assessment and management tool at a higher level allows for simultaneous research *and* development on the ground through a unique combination of research, extension and education.

Producer organizations may be particularly interested in assessing the situation of producers with RISE, and in identifying interventions and measures which can contribute to securing livelihoods and strengthening their position in the market.

Development projects are at a first stage interested in the identification of entry points to improve the sustainability of agricultural production, (i.e., in determining where to invest efforts and funds). RISE assessments can be particularly useful for a *holistic* monitoring of the development and a *holistic* impact assessment with regard to measures implemented.

Political institutions are often interested in the identification of strengths and weaknesses in order to elaborate strategies to render agricultural production more sustainable. RISE assessments allow for such overviews, which also allow for the identification of changes to framework conditions (regulations, price policies and direct payments). To monitor the development of sustainability, a *holistic* assessment is particularly important, since evaluations focusing on specific aspects may lead to erroneous conclusions about the actual conditions on the ground. Yet another interesting benefit of RISE for political institutions is that it allows for comparisons between different farming systems, sectors, regions or even nations. This makes it possible to depict specific advantages of location with regard to the sustainability of agricultural production and to communicate the message to relevant audiences (e.g., to consumers).

The processing industry and retailers are interested in identifying bottlenecks, which could threaten a persistent supply of high quality raw material produced in a way acceptable to consumers. Therefore, holistic sustainability assessments can function as an early warning system and pinpoint potential measures to improve the situation.

For label organizations, RISE may also be of benefit (e.g., certifying organic production or BSCI).[1] Label organizations can make use of the tool as a complementary add-on to certification in order to get a holistic view of the sustainability of the production of agricultural goods. Although RISE is not designed to serve as a certification instrument, it may add value to the certification process (e.g., as a monitoring tool and by assessing the impact of measures that have been initiated by the label organization).

1 BSCI: Business Social Compliance Initiative. The BSCI is the European approach to improve social performance in supplier countries through a uniform social standards monitoring solution for retail, industry and importers.

Last but not least, RISE may serve as a valuable instrument in education and training. Based on its holistic approach, it can serve to raise the understanding of the complexity of sustainability in its three dimensions. It may increase conscience and awareness of sustainability issues, and initiate a change of mindset with relevant actors in agricultural production.

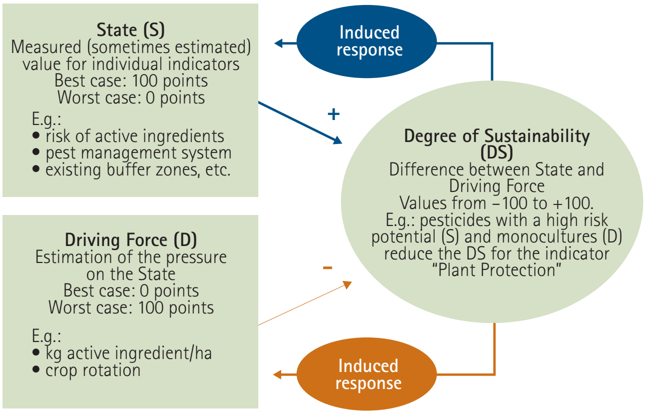
RISE methodology

The RISE analysis depicts ecological, economic and social aspects of the sustainability of agricultural production on the basis of twelve indicators, which are calculated from more than 60 parameters.

State and driving force

Each indicator contains parameters that either outline the State (S) of the system or describe a pressure on or Driving force (D) within the system, driving it in a certain development direction. State parameters have a value between 0 (worst case) and 100 (best case). Driving force parameters are also computed on a scale between 0 and 100, but since they are valued as a negative pressure on the system, 0 depicts the best case and 100 the worst (biggest pressure).

Figure 1: Methodology to calculate the degree of sustainability.



The Degree of Sustainability (DS) is calculated as DS=S–D (Figure 1). Taking into account S-parameters as well as D-parameters not only allows for a static picture of the current situation but also reveals development trends of the system. Thus the RISE evaluation provides both an analytical snapshot of the farm situation while also describing some of the dynamics, which change the system over time. Assessing Driving forces makes it possible to understand and visualize trends and threats that may be decisive for an operational sustainability concept.

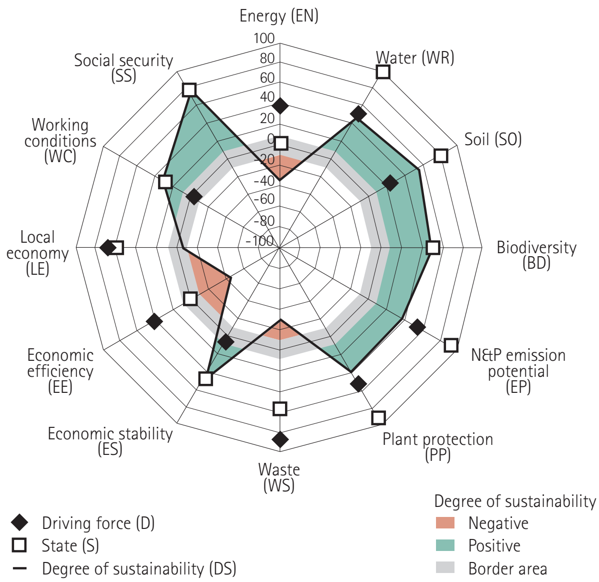
The principle of the RISE model is based on the DSR framework (Driving force-State-Response) for sustainable development of the UN (UN, 2001). The concept of the DSR model, originally developed to group mainly diagnostic indicators, is the basis for RISE but had to be tailored for the requirements expected of a management tool (also taking into account the fact that the allocation of State or Driving force parameters found in literature are not always consistent (cf., Daniel *et al*., 2003; Sanvido *et al*., 2004). Because RISE is focusing on sustainability-relevant practices, it is often management practices that are assessed rather than the results hereof (e.g., the quantity of applied pesticides instead of their content in the groundwater). However, the most significant difference between the RISE methodology and the DSR framework is the absence of response indicators and the computation of the degree of sustainability for each individual RISE indicator from the S- and D-parameters assessed.

The indicators and parameters

The output of the RISE model is designed in a way that the farmer can easily determine where problems exist and, thus, where interventions might lead to improvements. The sustainability polygon depicts twelve indicators covering ecological (natural resources, management), economic and social aspects fundamental to the sustainability of agricultural production:

Natural resources	• Energy • Water • Soil • Biodiversity
Management	• Emission potential (N&P) • Plant protection • Waste
Economy	• Economic stability • Economic efficiency • Local economy
Social situation	• Working conditions • Social security

Figure 2: The RISE sustainability polygon.



The RISE polygon (Figure 2) allows quick interpretation of the strengths (green area with DS>10) and weaknesses (red area where DS<-10) regarding the sustainability of the farm. Individual indicators are considered sustainable if the degree of sustainability is above +10, the whole farm/system is considered sustainable if no indicator has a degree of sustainability below -10. An optimal situation regarding the sustainability of the farm is not achieved by individual maxima on single indicators but much more through a balanced bandwidth of all indicators (at the highest possible level).

For every indicator, the state (current situation) and driving force (pressure on the system) are determined separately, each calculated from different parameters. A total of more than 60 parameters (Table 1) are individually valued in the model output, allowing the farmer to identify quite accurately strengths with regard to sustainability and where to intervene to improve the situation on his enterprise.

Once strengths and weaknesses for the 12 indicators are identified, they can be broken down into their S- and D-parameters in a next step to identify *specific* strengths and weaknesses in more detail. The different parameters considered during a RISE analysis are summarized in Table 1, sorted by their affiliation to the sustainability dimension, indicator and whether they are considered as a State or Driving force parameter.

Besides providing an overview of the sustainability situation in the RISE polygon, the standard output given to farmers covers processed information on 26 pages.

Table 1: Indicators and parameters used in RISE to evaluate the sustainability of agricultural production.

Dimension	Indicator	State Parameter (SP)	Driving Force Parameter (DP)
Natural resources	Energy	SP1: Environmental effect of the used energy carrier	DP1: Energy-input per hectare of farmland DP2: Energy-input per work force
Natural resources	Water	SP1: Water quantity and availability: SP1a: Based on the farm manager's point of view SP1b: Based on the data of WaterGAP SP2: Water quality and stability of the quality: SP2a: Based on the farm manager's point of view SP2b: Based on an "objective" source	DP1: Water quantity and productivity: DP1a: Water usage and productivity for plant production DP1b: Water usage for animal husbandry DP2: Risk factors for water quality DP2a: Water pollution by manure DP2b: Water pollution by silage leachate DP2c: Waste water production and treatment/disposal DP2d: Water protection by soil conservation/cultivation DP2e: Soil permeability (nutrients/pollutants)
Natural resources	Soil	SP1: Soil pH, salinization, water logging, soil analyzes. SP2: Erosion index: SP2a: Visible erosion SP2b: Erosion risk	DP1: Proportion of farmland treated with pesticides, acidifying fertilizers or fertilizers with heavy metals. DP2: Intensity of soil tillage DP3: Salinization due to irrigation without appropriate drainage DP4: Nutrient depletion

Dimension	Indicator	State Parameter (SP)	Driving Force Parameter (DP)
Natural resources	Biodiversity	SP1: Biodiversity promoting farming system	DP1: Proportion of intensely used farm land (usable agricultural area) of the total farmland DP2: Plot size DP3: Intensity of weed control
Management	N&P emission potential	SP1: N&P balance by production and demand SP2: Organic manure: SP2a: Manure storage SP2b: Application method	DP1: Quantity of N&P from organic and inorganic fertilizers (import-export)
Management	Plant protection	SP1: Application: SP1a: Education of the handler SP1b: Apparatus check SP1c: Storage of plant protection products SP1d: Compliance with waiting period SP1e: Adherence of buffer zones along waterways SP2: Environmental and human-toxicological risks (effects on non-target organisms, persistence, acute toxicity, chronic toxicity)	DP1: Cropping system: DP1a: N-Fertilization (over-saturation) DP1b: Proportion of farmland treated with pesticides DP1c: Variety selection DP1d: Damage threshold, prognosis, selection of active ingredients DP1e: Biodiversity DP1f: Bonus for further relevant measures DP2: Crop rotation
Management	Waste	SP1: Potential as environmental hazard SP2: Waste disposal	DP1: Waste produced on the farm (type and quantity)
Economy	Economic stability	SP1: Net debt service over change in owner's equity and paid interest SP2: Equity ratio SP3: Gross investment	DP1: Cash flow/raw performance rate DP2: Dynamic gearing DP3: Condition of the machines, buildings and permanent crops

Dimension	Indicator	State Parameter (SP)	Driving Force Parameter (DP)
Economy	Economic efficiency	SP1: Return on assets SP2: Return on equity SP3: Total earned income	DP1: Productivity
Economy/ Social situation	Local economy	SP1: Share of regional working forces and salaries SP2: Lowest salary on farm compared with the regional average gross income	DP1: Raw performance per ha farmland and year
Social situation	Working conditions	SP1: Emergency/ medical care on site SP2: Provision of potable water SP3: Accommodation and sanitary equipment SP4: Working hours SP5: Wage discrimination SP6: Child labor SP7: Forced labor	DP1: Continuing education DP2: Encumbering work DP3: Working conditions as perceived by the workforce DP4: Disparity in income DP5: Working time for reaching minimal wage
Social situation	Social security	SP1: Social security: SP1a: Precaution (compulsory and voluntary solutions) for retirement, unemployment, health, accident and disability SP1b: Protection from dismissal in case of sickness, accident or maternity SP2: Means of subsistence	DP1: Potentially payable salary DP2: Farm succession plan DP3: Legality and documentation of employment DP3a: Residence permit status of employees DP3b: Employment contract DP3c: Working permit

Due to its characteristics as a management tool for agricultural production systems the environmental indicators of RISE appear in larger number and slightly more prominent than the others. Some of them relate to natural resources *per se* while others are associated with management practices. In particular the number of parameters required to calculate the indicators is not consistently held equal for each one of them but is based on factual and textual criteria. The indicators and their parameters were selected in a way to allow the farm manager (or other relevant entities) to exert an influence on the sustainability situation and development ("response-inducing"). Expert knowledge and the help of specialists is the foundation for the definition of all indicators and parameters while the tool was and still is being continuously tested in practical applications and being improved in an iterative process.

Since the RISE sustainability analysis focuses on agricultural production on a farm, the spatial system boundary of the model is outlined by the total farm land (ha usable agricultural area) or the company surface (not included is the private space of farm family members or income from para-agriculture). For farming systems with barely any or no productive surface an alternative calculation model including the whole supply chain still needs to be developed. The temporal system boundary is provided by a bookkeeping year.

Evaluation of tea farms in southern India

Study area

The district of Nilgiris, Tamil Nadu, India is a hilly region and the analyzed farms are in an area with an elevation of 700 to 1,200 meters above sea level. Tea is the main source of income and it shapes the landscape of the district. There are 15 Industrial Cooperative tea factories (*INDCO*s) uniting 20,300 small tea growers cultivating less than six hectares each and producing 17 per cent of the total tea production in the district of Nilgiris. In addition to the *INDCO* factories private tea processors collect leaves from other small farms. Big estates of sometimes more than 1,000 hectares with their own tea factories are further key players. Suppliers collect the green tea leaves from farmers and pay them the *INDCO* price, which is based on the price for black tea sold at public auctions. The tea processors do not have control over payments to the farmers, but generally the *INDCO* price is known among all farmers. As the tea price has been low from 2003–2005, the government of Tamil Nadu intervened in favour of the small farmers. Small tea growers that own up to four hectares were eligible to benefit from a "Price Stabilization Fund Scheme."

Objective

The application of the RISE model on a sample of 13 tea growing farms with three to 63 hectares in the district of Nilgiris was requested by a tea processor. Since tea growers provide the basic resource for the tea manufacturing unit it was considered important to analyze the sustainability of the prevailing tea production systems as well as possible future threats for these farms. The findings of the assessment, i.e., potentials, critical deficiencies and possible risks of the current production systems, were to be presented to and discussed with the farmers in order to develop ideas and encourage steps of action to improve the situation where necessary. Furthermore, the tea processor was particularly interested in evaluating whether higher quantities of tea could be profitably produced without compromising ecological and social aspects of sustainability, because he was planning to expand the tea processing unit. It was further foreseen that, at a later stage, the changes in production practices would be monitored by using the RISE-tool, and the effectiveness of the measures taken could thereby be verified.

The processor was interested in evaluating a small number of its roughly 500 tea producers with RISE. He preferred such a case study with farms that he thought to be typical rather than a study with a representative sample.

Results

The results of the 13 farms analyzed are displayed in Table 2 and a summarizing sustainability polygon is shown in Figure 3. The polygon depicts mean values of S, D and DS for each indicator of the 13 farms. Some indicators show high variation, others vary only slightly from farm to farm (Figure 4).

Ecological indicators

- *Energy EN, Water WR, Waste WS and Soil SO:* in general a good performance was observed for these indicators. The outlier on the indicator "Energy" (EN) represents a farm that uses two tractors for the farming operation and oil for irrigation. The outliers in the indicator "Water" (WR) stand for two farms with irrigation from water sources that are unstable. The positive result for the indicator Waste WS is due to the small amount of waste produced at farm level. It consists of fertilizer bags and containers for pesticides. The disposal of litter on farm is problematic: In most cases farmers dig a hole to discard the waste or simply throw it in an unused well; water used for cleaning spraying implements is discarded on bare soil. Though the amount of produced waste is low, a risk of ground water contamination exists.

Plots with an inclination of more than 30 per cent were recorded regularly. Perennial crop coverage, anti-erosion measures like drenches and ditches, and contour cropping to avoid run-off are generally practiced.

Table 2: Degree of Sustainability (DS) for the 12 RISE indicators on each of the farms assessed. Acronyms cf., Figure 3. Farms are sorted according to farm size, from 2.8 to 10ha for small and from 22.8 to 62.9ha for large farms.

		Ecology							Economy			Society	
Size	Farm	EN	WR	SO	BD	EP	PP	WS	ES	EE	LE	WC	SS
Small (≤10ha)	1	99	86	58 1	2	38	6	35	41	-86	50	20	-37
	2	100	89	36	11	22	6	46	-17	-97	50	9	-38
	3	95	86	33	0	88	18	46	-33	-99	50	13	-49
	4	100	89	65	6	-51	-6	46	-50	-95	50	22	-46
	5	100	86	49	10	65	22	37	-59	-95	50	10	-54
	6	86	64	43	2	52	32	46	22	-62	50	25	-48
	7	96	88	30	-9	54	12	46	50	82	46	6	-18
Small	Mean	97	84	45	5	38	13	43	-7	-65	49	15	-41
Large (>10ha)	8	52	86	45	-6	-19	6	35	62	68	50	12	-15
	9	84	86	65	3	-20	21	64	-51	-97	50	17	-54
	10	100	89	35	-28	87	2	46	18	-76	50	24	-56
	11	99	59	25	-15	-18	-3	46	86	-35	50	11	-36
	12	96	86	9	-31	59	10	46	9	-95	50	25	-33
	13	100	86	34	-12	71	84	29	11	90	48	0	-9
Large	Mean	89	82	36	-15	27	20	44	23	-24	50	15	-34
Total	Mean	93	83	41	-4	33	16	44	7	-46	50	15	-38

Positive (Sustainable value)
Border area (Threshold value)
Negative (Non-sustainable value)

- *Biodiversity BD:* showed accentuated deficiencies, particularly with regard to the wild flora; only three of 13 farms are considered sustainable. This is mainly due to a high intensity of production that includes the fertilization of *all* plots, regular pesticide applications and a lack of ecologically valuable field margins. Inter-cropping is a general practice. All farms produce pepper, a majority also produce betel nut (areca nut) and (some) coconut palm. Coffee used to be grown commonly, but some have completely removed it due to low prices over the last decade. Some farmers grow different spice crops, especially cardamom. They further grow fruit trees like bananas, mango, papaya, jackfruit etc., mainly for their own consumption.

Figure 3: Synthesis on the RISE polygon of the 13 assessed farms; means of the 12 indicators, cf., Table 2.

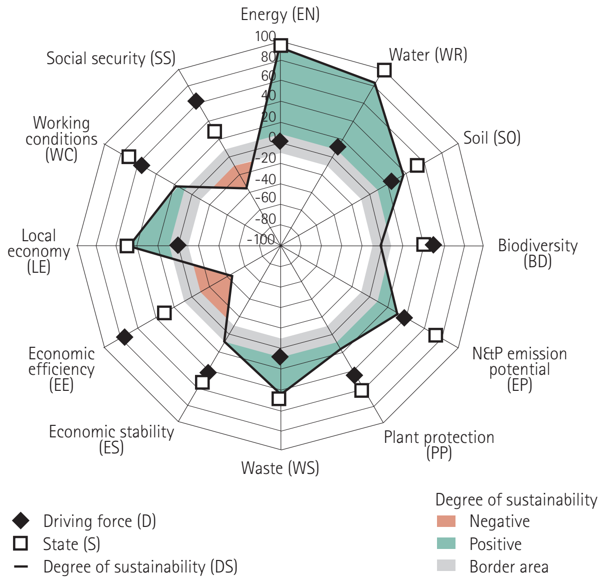
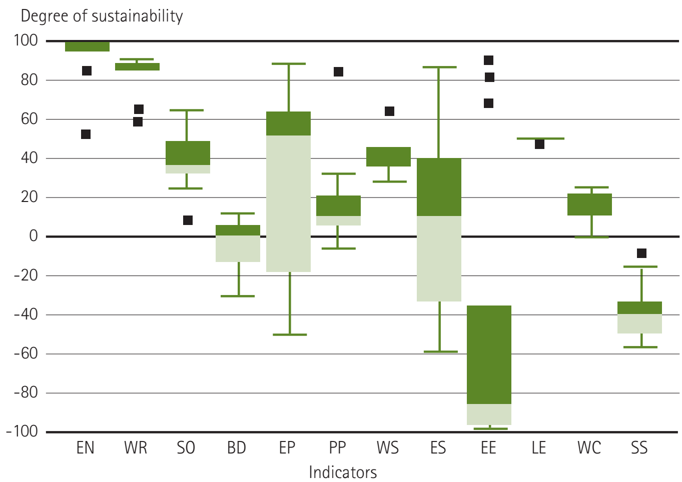


Figure 4: Box-Plots of the 12 indicators for the 13 farms; acronyms cf., Figure 3.



- *N&P Emission Potential EP (nine of 13 farms sustainable); and Plant Protection PP* (six of 13 farms sustainable): these indicators vary considerably among the farms due to different practices. Deficiencies are due to high quantities of fertilizers (mainly organic manure) applied on some farms that do not match with the crop requirements. For all farms an appropriate education for plant protection and especially integrated pest management (Boller *et al*,. 2004a; Häni *et al*., 1998) is missing, application units (sprayers, nozzles, etc.) are not inspected on a regular basis, and buffer zones along waterways and water sources are lacking.

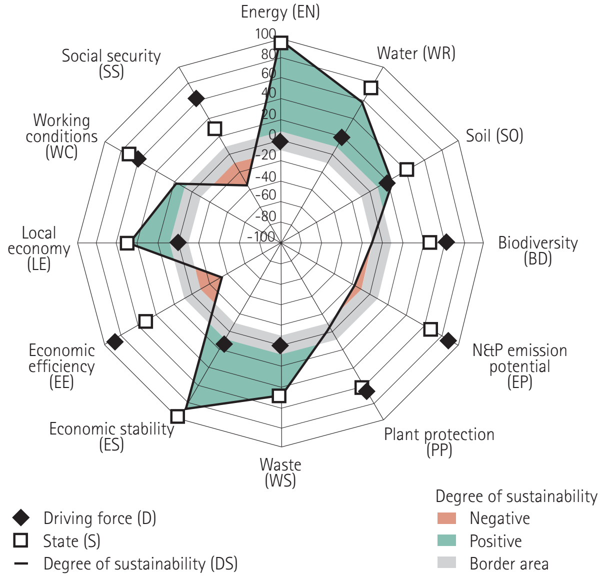
Economic indicators

- *Economic Stability ES:* larger farms achieved a better performance generally regarding this indicator than small farms (_10ha). Five of the six large farms, but only three of the seven small farms, are considered sustainable with regard to ES. The debt burden is generally low due to restricted access to credit. Only on five farms have substantial investments been undertaken over the last five years, but the state of the tea plantations is usually good. Some coffee fields, however, were in mediocre condition because they were neglected due to low commodity prices.
- *Economic Efficiency EE:* the economic efficiency of most farms evaluated is poor (only four of 13 are sustainable). The high values of tea plantations in contrast to the low incomes result in a low return on investment.
- *Local Economy LE:* the well-maintained tea plantations are able to produce up to 25,000 kg of green leaves per year and hectare (equivalent to 5,500 kg of processed tea). This is sufficient to provide on average more than two regional employees with a regular, though low income, common to the region—Indian Gross National Income in 2003 was only US$540 per capita and year (World Bank, 2005). Therefore, the LE indicator is considered sustainable for all evaluated tea farms.

Social indicators

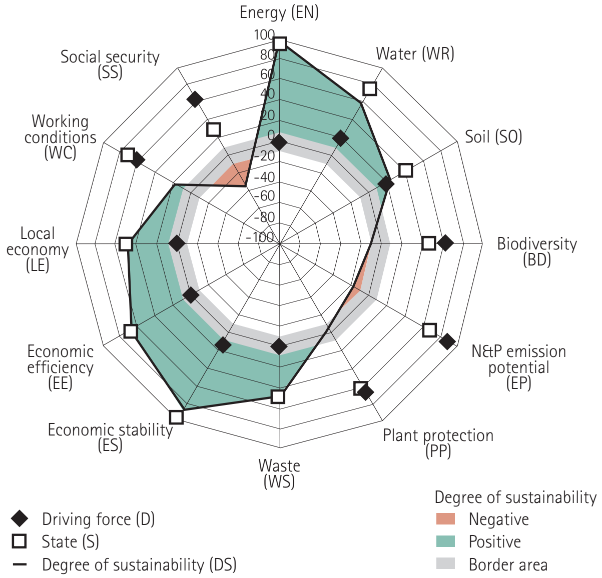
- *Working Conditions WC:* due to the generally sufficient results for the State parameters (e.g., no child or forced labour, availability of potable water and sanitary equipment) this indicator is considered sustainable for nine of the 13 analyzed farms. However, the Driving force parameters were rather high. A big gap between potentially payable and effectively paid salaries, lack of overtime compensation, unpaid holidays, heavy labour and missing training opportunities, exert a high pressure on the future development of tea plantations. Here the RISE-Tool shows its capacity as early warning system.

Figure 5: Standard calculation for farm No. 11 with an interest rate on the owners' equity of 4.6 per cent.



- *Social Security SS:* this is a common sustainability issue on all evaluated tea farms. Old age pension schemes, insurance for unemployment, health, accident and disability and protection against loss of earnings and dismissal do not exist. Some employees may profit from private solutions, since farm owners generally bear the expenses in the case of an accident; not to do so may have a negative effect on reputation. However in the case of illness, employees are not protected at all. In contrast, farm managers/owners have a high living standard and in general a family network replacing an old-age pension scheme as well as health and accident insurances. The salaries paid by all farmers are below what would be needed for an acceptable existence (i.e., a life of dignity). Salaries for the tea pickers are particular low. Although large farms (>10ha) have to pay legally fixed minimum salaries (still below the minimum existence income!), they avoid adhering to this regulation by splitting the property into several legal entities (<10ha).

Figure 6: Indicators calculated for farm No. 11 without an interest rate on the owners' equity.



Discussion

Value of assets and return on investment

Figures 5 and 6 display the situation as analyzed on farm No. 11, once with an imputed return on investment (ROI) of 4.6 per cent (Figure 5) based on the average government bond yield of the evaluation year (Reserve Bank of India, 2005) and once without subtracting the imputed return on assets from net profit/loss (Figure 6). The comparison of the two figures highlights the impact of the return on the owner's equity on the net profit/loss and, therefore, on the different indicators. Based on the interviews, a market value of roughly 400,000 INR (US$8,800) per acre (0.405ha) of tea was assumed for the Nilgiris district. The World Bank reported an inflation rate of 5.4 per cent for 2004. For the same year the average government bonds yielded 4.6 per cent. It can be assumed that the land under tea cultivation is inflation neutral or even gains in value over the long-term. Interestingly enough, after setting the ROI rate to zero only four farms still accounted for a critical economic loss.

Farmers often ignore ROI and sometimes do so for good reasons. More important to them is to get a decent remuneration from tea production. The demand for land, which leads to high prices per hectare, indicates that there must be several advantages to invest in land. One reason may be that a tea plantation generates a regular income and in the long run will allow a reasonable standard of living. For tea farmers prestige may also play an important role. To achieve higher status in society, one needs to increase the size of the farm.

Minimum salary

A factor that needs to be defined for the RISE analysis is the minimum salary per year per household (family with two children) which allows for a life of dignity, considering minimum living standards (minimum existence income) in the area where the evaluation takes place. Based on triangulation interviews with different tea stakeholders and independent local representatives, US$800 was used in the study as a "minimum salary" (*minimum existence income*) supposed as being sufficient to sustain a family with basic demands for a year (food, clothes, housing, hygiene, basic education and basic precautionary measures). Furthermore, we assumed that a salary of US$270 per year would be the utmost minimum to survive (just enough food, an absolute minimum of clothes and housing). Figures 7 and 8 display the calculations of a single farm polygon based on a "minimum salary" of US$800 and US$270, respectively. Applying the realistic *minimum existence income* of US$800, not a single farm of the evaluated sample reached sustainable values for the indicator "Social Security" (Figure 7). Even assuming a minimum salary as low as US$270 improves the picture only marginally (Figure 8). The slightly higher "Social Security" and "Economic Efficiency" are misleading because they are based on a minimum salary that only allows for bare survival of the employees.

If the farmers would pay a realistic minimum existence income (i.e., US$800) to all employees, this would of course drastically decrease the relatively high income of the farmers themselves. The big gap between potentially payable and effectively paid salaries (cf., high driving force in the indicator "working conditions") is causing a high risk for social conflicts. An increase of salaries is therefore not only important for the employees but also of high relevance to the processor, in view of creating a more stable social and economic business background.

Figure 7: RISE polygon of farm No. 8 assuming a minimum salary of US$800/year (allowing a life with basic demands).

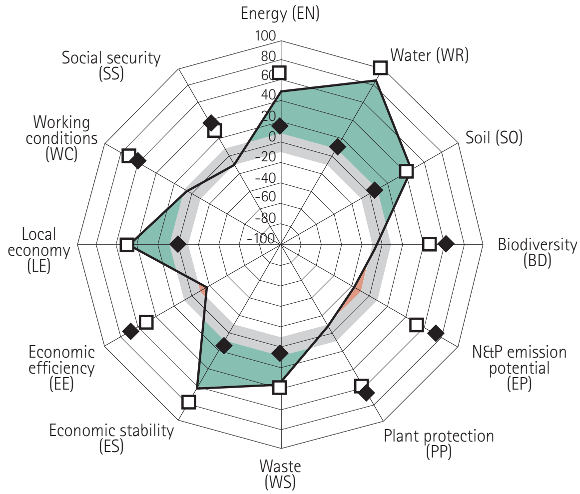
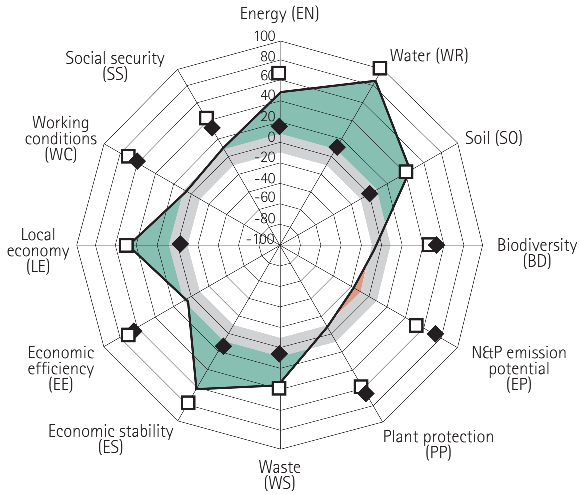


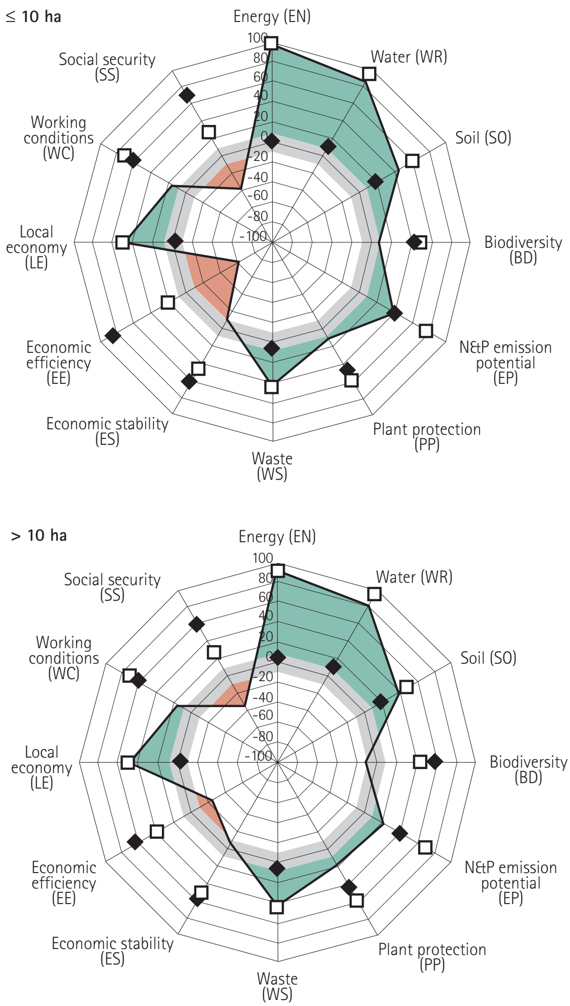
Figure 8: RISE polygon of farm No. 8 assuming a minimum salary of US$270/year (only allowing for bare survival).



Comparison of small and relatively large farms

To allow for a comparison of small farms with farms larger than 10ha, two summarizing polygons using the average indicator values for the two farm types were calculated from the evaluated sample (Figure 9), and box-plots presented by farm size (Figure 10). Substantial differences regarding average values between small and large farms appear in

Figure 9: Comparison of the mean indicators for farms smaller than 10 ha and those bigger.



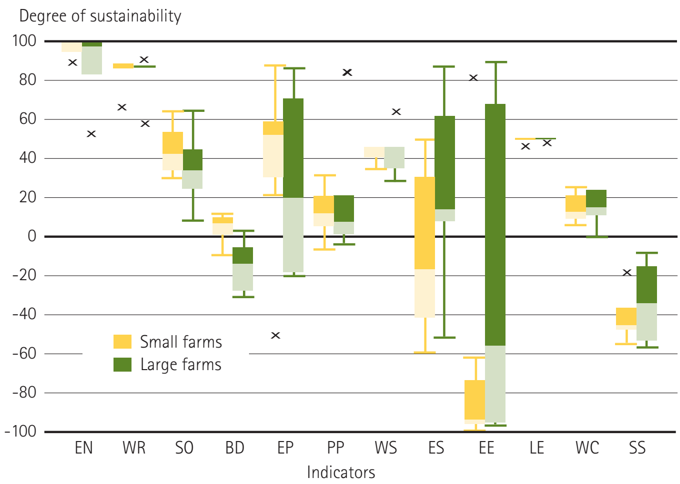
Economic Efficiency (EE), Economic Security (ES) and Biodiversity (BD). The EE indicator shows a tendency for large farms to achieve a better efficiency. However, the massive variance indicates that good management of the farm is required to achieve a profitable farm operation. Also with regard to Economic Security (ES) the large farms seem to out perform small ones.

Just the opposite is true for the indicator *Biodiversity BD*, where small farms yielded significantly better results than large ones. In general, the smaller the farm, the smaller (and therefore more diverse) the plots (cf., Boller *et al.*, 2004b). In addition, the bigger farms grow fewer shade trees. Since this is not an economic necessity, the situation on large farms could be improved through appropriate awareness-building and support in practical application.

The ecological indicators *Soil SO* and *Emission Potential EP* tend to yield slightly inferior results for larger farms; this indicates that on bigger farms, the situation regarding environmental issues has to be observed more cautiously.

In the domains of *Energy, Water, Waste, Plant Protection, Local Economy, Working Conditions* and *Social Security*, there appear to be no differences between smaller and bigger farms.

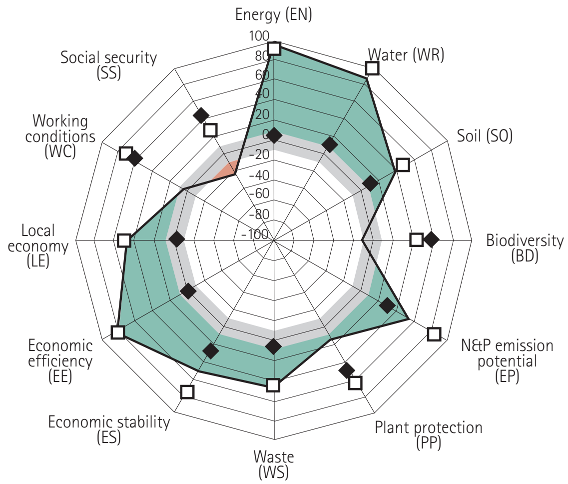
Figure 10: Box-plots of the 12 indicators split according to farm size (left < 10ha "small" vs. right > 10 ha "large" farms). Statistically significant differences only on Biodiversity based on a Mann-Whitney U Test. Acronyms cf., Figure 3.

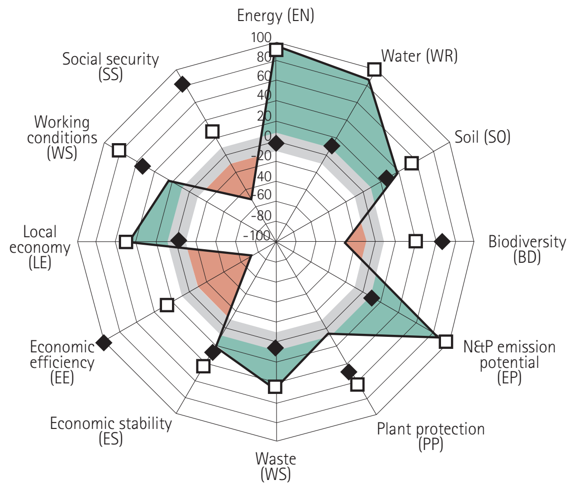


Potential to increase tea production

Increases of tea yield appear possible without much negative effect with regard to ecological aspects provided that the level of education and awareness is improved. This can be concluded by comparing the sustainability polygons of two farms, one producing twice the yield/ha than the other (Figure 11).

Figure 11: Farm No. 7 (top) achieves double the tea yield per acre than farm No. 10 (bottom).





Higher yields may be achieved by increased use of fertilizers and pesticides. Inappropriate applications of these fertilizers may pose a high risk for pollution of the water resources. An increased N-fertilization will further demand higher pesticide applications because of higher disease pressure. Therefore good farm management practices, awareness of the principles of Integrated Pest Management (IPM), and education of those who are involved in pesticide application are prerequisites to avoid possible problems in the domain of ecology and health.

Tea yield could also be increased and kept at a more constant level through irrigation. However, irrigation during the dry season might require major investments into irrigation equipment. Increased irrigation of the tea crop could lead to a competition for drinking water in the dry season, and water scarcity may result as a problem in the future.

Additional aspects

Some other issues that have arisen from the RISE evaluation are discussed in short:

- Child labour as such is not present in the tea plantations. But since salaries are very low and there is a lot of work available for women (plucking is a job exclusively done by women), children must help out with the workload in most households, which is difficult to assess and evaluate.
- To get closer to an environmentally sound production several actions can be suggested:
  - Some farmers have a good knowledge of and practical experience with Integrated Pest Management (IPM). This potential needs to be supported and further developed and the knowledge about IPM practices has to be dispersed among other farmers.
  - For the application of pesticides, appropriate education or training should be mandatory. Education will reduce mistakes and undesirable side effects while increasing the effectiveness of pesticide applications. Additionally, the risks of built up resistance can be diminished with correct application.
  - The red spider mite *Tetranychus cinnabarinus* is a problem on big estates (with several hundred hectares) in the Nilgiris district, although tea is only a secondary host for this pest (CABI, 2002). This may be the result of a reduced biodiversity because larger fields lack ecological compen-

sation and exhibit more insecticide resistance due to a more intensive use of pesticides. However, the farms assessed in this case study didn't show problems regarding this pest. To save this comparative advantage it is important that they keep and even improve the biodiversity and good IPM practices (Boller *et al*., 2004a).

- Fungicides containing copper should be replaced, e.g., by the available substitute Contaf (five per cent EC of Hexaconazole), which is assumed to be more environmentally friendly.
- Ecologically valuable field margins are rare. Farmers should not only know that such border areas may provide habitats for pests. Rather, they should become aware about their potential as habitats for natural predators and, as a consequence, their importance as resources of natural regulation and buffer zones. If such zones were established, a more balanced and stable agro-ecological system could be installed, which may decrease the number of intervention measures required (Boller *et al*., 2004b).

Conclusion

Tea can be considered a site-adapted crop to the region of the Nilgiris, Tamil Nadu, India, but in particular small farmers are under great economic pressure. For the ecological situation intervention points were identified for the improvement of pest management, nutrient management and biodiversity. The social situation of farm labour is clearly insufficient due mainly to the very low salaries of employees, especially of tea pickers, resulting in a potential for social conflict. Efforts to improve this situation are urgent.

The RISE assessment showed that an increased and balanced tea yield per farm is possible without causing negative effects regarding sustainability. This could be obtained by optimizing fertilization and plant protection. Irrigation might be an interesting option, but would need prior research on effects on water availability and on other possible negative side effects. Any measures have to be cautiously implemented and need agronomic advice and supervision. Increased productivity may lead to a win-win situation for processors, farmers and employees if a more regular and higher income is being used to improve the situation for all stakeholders. To ensure this, a dialogue with the farmers, employees and all involved stakeholders is of paramount importance. RISE can serve as a key tool for such a dialogue by visualizing the holistic performance of farms. The RISE assessment has been able to generate valuable managerial information relevant to Indian tea producers and processors. Overall, the project underlines the practical flexibility of RISE as a holistic, comprehensive and worldwide applicable tool.

The application of RISE on the small sample of Indian tea farms confirms that this relatively simple tool allows for identification of strengths and weaknesses with regard to ecological, economic and social aspects of sustainability. The tool can detect important intervention points and therefore act as a response-inducing tool. It has to be noted, however, that the conclusions are limited to the farms analyzed and to get a representative picture, well-defined larger samples of farms would have to be evaluated. As could be shown in other projects, e.g., in China, with larger and more representative samples, RISE is also a very valuable tool at higher organizational levels and especially for political objectives (Häni *et al.*, 2003a; Studer *et al.*, 2006). Recommendations may target specific farming practices as well as framework conditions in a way to achieve more sustainable agriculture.

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Section 3

Agriculture Policy and Sustainability Assessment

Introduction

The development and use of agricultural indicators at the institutional level has been evolving over the past 15 years, with an increasing emphasis on pragmatic and strategic approaches. Advances in agricultural indicators, generally, have been driven by an increasing demand for better information, as policy-makers, producers, shareholders and the general public have become concerned about a wide range of sustainability issues. While information on economic performance in agriculture has generally been available in the form of macro- and micro-economic measures, the evidence base for environmental and social issues had to be significantly and systematically strengthened.

Parallel to academic research on indicators, governments and other organizations have initiated indicator programs that more directly address policy needs. Whether linked to the need to design, monitor and evaluate regulatory or market-based policies; to communicate trends to the general public; or to help track risks associated with supply chains, these efforts are ultimately driven by the need to regularly produce information that can be used in a practical context.

Nevertheless, the envisioned potential of indicators to inform decision-making effectively continues to be constrained by various technical, conceptual and institutional limitations. Similar limitations tend to appear across other sectors, and they are no less relevant for the agricultural sector. They also appear across scales, whether one's focus is on the farm, regional, national or international level. Authors in this section point to partnerships and networks as an important mechanism for the harmonization of efforts and learning.

Chapters in this section review indicator initiatives on the national and international level that are linked to a wide range of policy agendas. Most are centered on indicators in physical units, but several, such as Strain and Lefebvre and Legg emphasize the need to develop monetary values to capture positive and negative externalities where feasible, as this helps design and calibrate economic policy instruments.

The first two papers in this section provide snapshots of agri-sustainability indicators at the national level. The Swiss Federal Office for Agriculture (FOAG) paper outlines the constitutional basis for monitoring sustainability; discusses a conceptual framework for sustainability indicator development; and provides recent data on agricultural indicators. Agriculture and Agri-Food Canada's paper outlines the development of agri-sustainability indicators and the connections these indicators have with policy. An integrated modelling approach that links indicators with a policy model, the Canadian Regional Agricultural Model (CRAM), is explained.

The latter half of the section consists of contributions from the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization (FAO) describing the evolution of agri-sustainability indicators, trends in agricultural policy and several limitations and constraints associated with the development and use of indicators. FAO provides a summary of FAO-related work and outlines a number of institutions and organizations for potential partnerships and networking.

Indicator selection, analysis and reporting, is typically guided by criteria and conceptual frameworks. In this compilation the frameworks described include: Driving Force-State-Response (DSR; Legg, this volume); Pressure-State-Response (Strain and Lefebvre, this volume), which is essentially the same as DSR; and finally, a theme-based approach of equity, efficiency and resources (Bötsch and Jung, this volume). A broad array of indicator selection criteria are also put forward, including policy relevance, analytical soundness, measurability, feasibility and ease of interpretation (Legg, this volume; Sérvin, this volume). Besides helping to structure indicators, some of the frameworks—such as the DSR framework—can also help analyze causal linkages between different factors relevant for agricultural policy.

Amidst a proliferation of agri-sustainability indicators, various technical and institutional constraints are yet to be overcome, as discussed by Legg and Sérvin. Technical constraints speak to data quality and quantity issues, such as requirements for relevant, up-to-date, reliable, consistent, coherent and interoperable data. Along similar lines, definitions and methodologies that enable broader standardization and harmonization are being called for, particularly when data are collected across regions and scales (Legg, this volume; Sérvin, this volume). Institutional limitations speak to high monitoring costs, lack of coherency, data access issues and the accurate interpretation of results. Many of these challenges are also relevant for more research-oriented indicator efforts, but they are particularly important when indicators are to be operationalized, and used more consistently for planning, analysis and reporting.

Understanding the effects of existing or planned policies are key concerns for all stakeholders in agriculture. Indicators can be used in constructing integrated policy models that can help analyze the effects of alternative policy measures. Strain and Lefebvre in this volume provide an example where an indicators-based analysis of the effects of alternative best management practices informs the negotiation of target levels in agri-sustainability policy implementation agreements.

Overall, authors confirm that agri-sustainability indicators are increasingly a functional part of national and international information systems, and that cross-scale approaches provide a key to progress in this area.

Sustainability: Guiding principle for Swiss agricultural policy

Manfred Bötsch and Vinzenz Jung

M. BÖTSCH – Swiss Federal Office for Agriculture (FOAG), Federal Department of Economic Affairs, Mattenhofstrasse 5, 3003 Berne, Switzerland.

V. JUNG – Swiss Federal Office for Agriculture (FOAG), Federal Department of Economic Affairs, Mattenhofstrasse 5, 3003 Berne, Switzerland.

Abstract

Agricultural sustainability was first inscribed in the Swiss Constitutional Article in 1996. Evaluation of economic, social and ecological dimensions of agricultural sustainability, as well as the effects of corresponding agricultural policies, is undertaken by the Swiss Federal Office for Agriculture (FOAG). Progress is monitored using agricultural indicators that are framed conceptually by sustainability concepts of resources, efficiency and equity. Resources refer to the availability of natural, human and asset resources for future generations. Efficiency refers to the efficient use of renewable and non-renewable resources. Equity refers to equitable welfare distribution between present and future generations, within the present generation and between industrial and developing countries. Following these themes, the 2005 Agricultural Report includes 15 years of data on the 11 currently available indicator categories. Indicator trends and interpretations are reported in this paper.

Keywords: Swiss agricultural policy, sustainability evaluation, sustainability indicators for agriculture.

1.Introduction

In 1997, the Swiss government (Federal Council) approved a first sustainability strategy for Switzerland (Schweizer Bundesrat, 1997). In 1999, the Swiss people approved a new Federal Constitution, in which sustainability was enshrined as a guiding principle for public action in all areas. The word "sustainability" appeared in the Constitution for the first time in 1996 in the new article on agriculture.

The regulation on the evaluation of agricultural sustainability foresees that the Swiss Federal Office for Agriculture (FOAG) evaluates the economic, social and ecological situation in agriculture as well as the effects of the corresponding agricultural policies. The instruments used include monitoring indicators as well as a more restricted set of sustainability indicators.

The conceptual framework for the indicators is similar to that developed on behalf of the "Swiss Interdepartmental Committee on Sustainable Development" (Mauch Consulting, *et al.*, 2001) and the Swiss monitoring system MONET.[1] Furthermore, it is in line with work carried out by the European Commission (2001).

2. Concept

The aim of sustainable development is to enable future generations to reach a welfare level that is comparable to that experienced today. Welfare means well-being, and is based on satisfying material and immaterial human needs. To realize these needs, certain levels of *resources* with defined qualities must be available to future generations. Resources in this sense include natural resources, human resources (knowledge) and reproduced resources (assets). Based on the definition of sustainable development, resources are a core element of the concept of sustainable development.

Because the quantitative and qualitative needs of future generations are unknown, and because it is impossible to estimate how technical progress will influence resource productivity and the degree of substitution between different resources, it is impossible to foresee the quantities

1 For various publications on MONET, see: http://www.bfs.admin.ch/bfs/portal/en/index/themen/nachhaltige_entwicklung/uebersicht/blank/publikationen.html.

and nature of resources that must be conveyed to future generations. Uncertainties exist, in particular concerning natural resources. For natural resources it is appropriate to attach utmost importance to the principle of precaution. Accordingly, natural resources must be used carefully. At the same time, substitution of non-renewable resources by renewable natural resources must be actively sought. Furthermore, renewable natural resources must be used in such a way that they can be regenerated, and human resources (knowledge) and reproducible resources must be actively and continuously renewed. Finally, the limited nature of all resources demands their *efficient use*.

Another central element of the sustainability concept is an equitable welfare distribution, not only between present and future generations, but also within the present generation. *Equity* within the present generation refers both to distribution within Switzerland and to distribution between industrial and developing countries.

Sustainable development should be a guiding principle at all levels of society. Each individual must make a contribution, but so should the economy and State. As a sector, agriculture can make a contribution. The size of agriculture's contribution depends on a combination of factors including its own sustainability practices. The following paragraphs show what agriculture's contribution can be and what framework conditions are necessary. The text is structured around three key sustainability themes: "resources", "efficiency" and "equity."

Resources

Agriculture's role in society is expressed in the corresponding constitutional mandate. Agriculture has to make a substantial contribution to the provision of food to the population, to the conservation of natural resources and the upkeep of rural landscapes as well as to a decentralized settlement of the country. By providing these goods and services, agriculture contributes to the welfare of society.

For agriculture to fulfill this mandate, the following three groups must make a contribution.

Farmers

In the production process, farmers must use natural resources carefully – the ability of natural resources to regenerate must be preserved (soil fertility, biodiversity, etc.). Also, they have to renew reproduced resources (farm buildings and equipment, machinery) regularly, and within the scope of their financial means. Finally, they have to acquire the necessary knowledge for sustainable farm management and keep it up to date.

Consumers

Consumer behaviour crucially affects the degree of agriculture's contribution to sustainable development. Consumers should develop a preference for products from sustainable agriculture and should also be prepared to pay an appropriate price.

State

The State has two tasks. Firstly, it must internationally defend the principles of sustainable development. Secondly, it must create or preserve the basic conditions at the national level that enable agriculture to make a maximum contribution to sustainable development.

Internationally coordinated action must aim to include external costs in the end price of products and services for all sectors of the economy. Such internalization is important for agriculture in two ways: firstly it decreases pressure from other industries on natural resources (air, water, soil and biodiversity) that are also used by agriculture. Secondly, it ensures that the prices of imported competitors' products also take into account true production-, processing- and distribution costs. Therefore, the ability of Swiss agriculture to compete would improve, and the pressures on natural resources would decrease.

At the national level, the State must ensure that agricultural operators receive compensation for the provision of public goods for which no markets exist. Landscape maintenance is one example: it brings direct advantages to the present generation, but also bequeaths these benefits to future generations. If the internalization of external costs is not fully implemented, the cost of preserving natural resources must be compensated for through direct payments that have to be contingent on ecological cross-compliance conditions. Border protection can also contribute to the preservation of natural resources.

In addition, the State must promote both sustainable production and consumer behaviour through education and extension measures.

Efficiency

The concept of sustainability requires that agriculture—like the remaining economy—deals efficiently with limited resources. This is also a necessary condition for competitiveness.

Equity

Agriculture contributes to intergenerational equity by maintaining its production potential. This includes careful handling of natural resources, regular renewal of machines and buildings and purposeful training.

Agriculture can contribute to improvements in intra-generational equity by contributing to employment, income, infrastructure and quality of life in rural areas.

3. Results of the first sustainability assessment carried out in 2005

The Agricultural Report 2005 for the first time uses indicators to show the extent of sustainability achieved in agriculture since 1990.

As explained earlier, the main themes of sustainability assessment relate to resources, efficiency and equity. Depending on the sustainability dimension (economic, social and ecological) each aspect carries a different weight. The question of resources occupies a central position in all three dimensions (natural capital, human capital and man-made capital). In addition, efficiency is a core aspect of the ecological and economic dimensions, while equity is a major aspect of the social dimension. It is not possible to decide whether a trend is sustainable from short-term developments. For this reason, indicators in the three dimensions of sustainability generally show trends since 1990. The following indicators were used for the three dimensions of sustainability:

	Economic	Social	Ecological
Resources	Capital renewal Land (area)	Education and training Quality of life	Biodiversity: ecological set-aside areas Water: sale of plant protection products Soil: excess phosphorus
Efficiency	Labour productivity		Nitrogen efficiency Energy efficiency
Equity		Comparison of labour income in agriculture and salaries among the rest of the population	

3.1. Results concerning the economic dimension of sustainability

The indicator for *capital renewal* measures the ratio of investment to total inventory of buildings, machinery and installations (= capital stock). It shows how many years it would take to replace the capital stock at the given rate of investment. Over time both capital stock and investment have decreased by around 10 per cent due to structural change. The results clearly indicate that capital stock is being renewed at the same rate now as at the beginning of the 1990s, (i.e., on average every 25 to 30 years, see Figure 1).

The second indicator, for *potentially arable land*, demonstrates the trend in relation to agricultural land which represents a substantial basis for agriculture's contribution to ensuring food supplies for the country's population. According to land-use statistics, the total area of potentially arable land has fallen by 2.1 per cent over the past 15 years (see Figure 2). This corresponds to almost half the area of Lake Neuchâtel. Almost all the farm land lost has been used for housing and infrastructure, which means that to a large extent, land surface has become impermeable and the land lost to agriculture from a long-term point of view. It is the task of spatial planning legislation to protect potentially arable land. There are no tools within the scope of agricultural policy that can be used to stop this trend.

The third indicator, for *labour productivity*, serves to measure how efficiently the labour force works in Swiss agriculture. Between 1990 and 2004, productivity rose by 1.4 per cent each year (see Figure 3).

The general picture regarding the economic dimension of sustainability is as follows:

Indicators	Assessment
Capital renewal	+ positive
Land (area)	- negative (not the result of agricultural policy)
Labour productivity	+ positive

3.2. Results concerning the social dimension of sustainability

The indicator for *education and training* shows the trend in education among farmers. The data concerning people with practical experience, basic schooling and further training were obtained from the census carried out by the Swiss Federal Statistical Office. They were collected in this form for the first time in 2003 (see Figure 4). That year around two-thirds of farmers had received a basic education or further training. From the point of view of sustainability, the higher the proportion of farmers with the relevant training the better. As only data for 2003 are available, it is not possible to assess the trend since 1990.

The indicator for the *quality of life index* shows the trend in quality of life among farmers and the rest of the population, based on their personal assessments. The quality of life index is obtained by combining estimated levels of satisfaction in 12 selected areas of life and their importance (sum of the products). Data concerning the quality of life index are only available for 2005; the level for farmers is lower than among the rest of the population. This can largely be explained by the fact that farmers are clearly less satisfied than non-farmers with regard to leisure time and time available.

The indicator for *labour income in comparison to the rest of the population* deals with the aspect of equity in the social dimension of sustainability. For this comparison, the income of a family labour unit is compared with the relevant salary of an employee outside the agricultural sector. Since this comparison has been made there has always been a difference between labour income in the agricultural sector and in other sectors of the economy. This difference increased between 1990 and 2004. It already increased considerably before the agricultural reforms of 1993, however, and has remained relatively constant since then (see Figure 5).

The general picture regarding the social dimension of sustainability is as follows:

Indicators	Assessment
Education and training	☐ no result
Quality of life: Comparison with rest of population	☐ no result
Labour income: Comparison with rest of population	– negative

3.3. Results concerning the ecological dimension of sustainability

The indicator for *ecological set-aside areas* shows how natural habitats are developing that help to maintain biodiversity and ensure the stability of ecosystems. Between 1993 and 2004 the total area of ecological set-aside land rose from 20,000 hectares to 116,000 hectares (see Figure

6). This constitutes 11 per cent of the total utilized agricultural area of Switzerland. From the point of view of sustainability, this trend is extremely positive.

Sales of *plant protection products* are an indicator of the risk of undesirable chemicals entering the environment, in particular water, soils and air. The quantity of plant protection products used in agriculture fell by 38 per cent between 1990 and 2004 (see Figure 7). Although it cannot be concluded that a reduction in the use of such products has a directly proportional effect on the environment, this marked trend must be seen as positive from the point of view of sustainability, especially when taking into account the fact that crop production has increased in that period.

The indicator for *excess phosphorus* compares input to output. Since phosphorus is a non-renewable resource, its economical application has high priority with regard to sustainability. Excess phosphorus should be avoided wherever possible. The amount of phosphorus used by Swiss farmers fell by almost two-thirds while efficiency increased by a factor of three between 1990 and 2002. Both are welcome steps towards the sustainable application (see Figure 8).

The indicator for *nitrogen efficiency* again compares input to output in agricultural production methods. The nitrogen cycle is complex and dynamic, and marked losses between input and output are unavoidable. It is estimated that with the intense agricultural production methods used today, the highest level of nitrogen efficiency that can be expected is around 30 per cent, owing to natural processes. In Switzerland, the nitrogen efficiency rate increased from 23 to 27 per cent between 1990 and 2002, which is again a positive trend from the point of view of sustainability (see Figure 9).

The indicator for *energy efficiency* compares energy consumption for production to the food calories produced. From the point of view of sustainability, energy efficiency needs to be improved and fossil energy sources should be replaced by renewable sources. In agriculture, energy efficiency has remained more or less unchanged since 1990 (see Figure 10). In terms of energy aspects, no progress has been made towards sustainability. Moreover, there has been no evident replacement of fossil fuels by renewable energy sources. It should be said, however, that agricultural policy has little influence on basic conditions with regard to energy.

The general picture regarding the ecological dimension of sustainability is as follows:

Indicators	Assessment
Ecological set-aside areas	+ positive
Sales of plant protection products	+ positive
Excess phosphorus	+ positive
Nitrogen efficiency	+ positive
Energy efficiency	- negative

Despite the positive trends in the first four indicators, not all ecological aims have been achieved. There are still further improvements that could be made, in particular in certain regions.

4. Conclusion

Sustainability is a guiding principle for Swiss agricultural policy. Sustainability indicators are used to monitor agriculture from a sustainability perspective. First results show that on the whole trends in agriculture since 1990 have remained sustainable in those areas where agricultural policy has had an impact. Sustainable agriculture will continue to be a key policy objective. The agricultural policy package "Agricultural Policy 2011," which was submitted to Parliament in 2006, represents a further important step.

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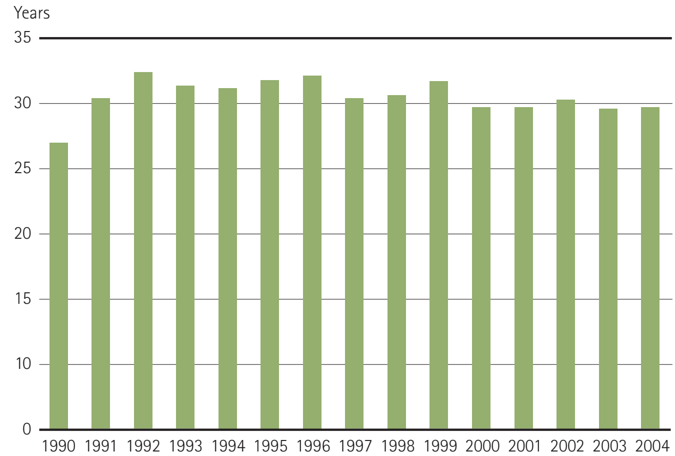
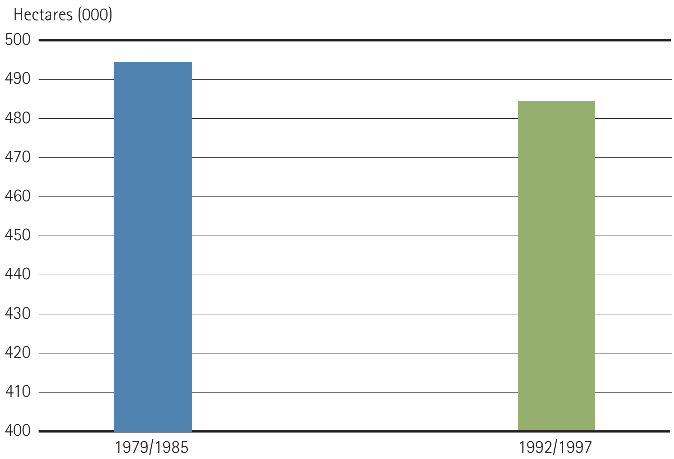
Appendix

Figure 1: Trend in capital renewal.



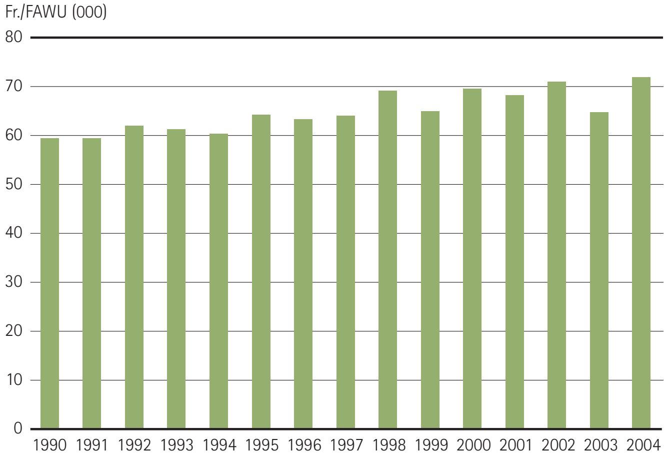
Source: SFSO

Figure 2: Trend in area of potentially arable land.



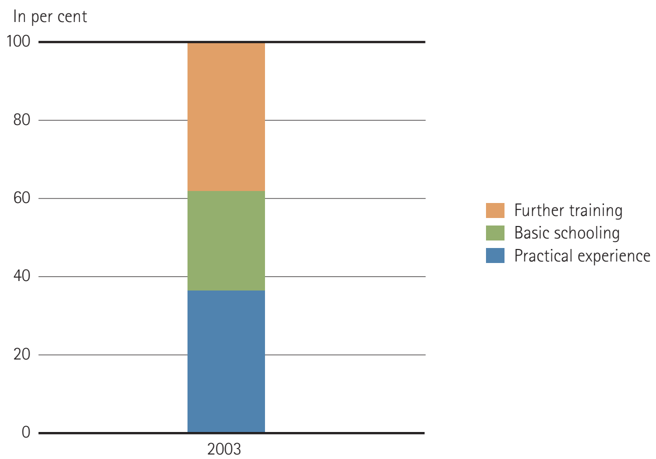
Source: SFSO

Figure 3: Trend in labour productivity.



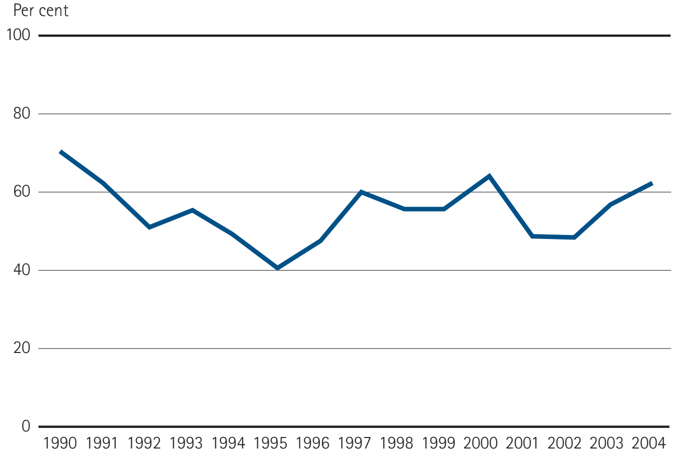
Source: SFSO

Figure 4: Education and training.



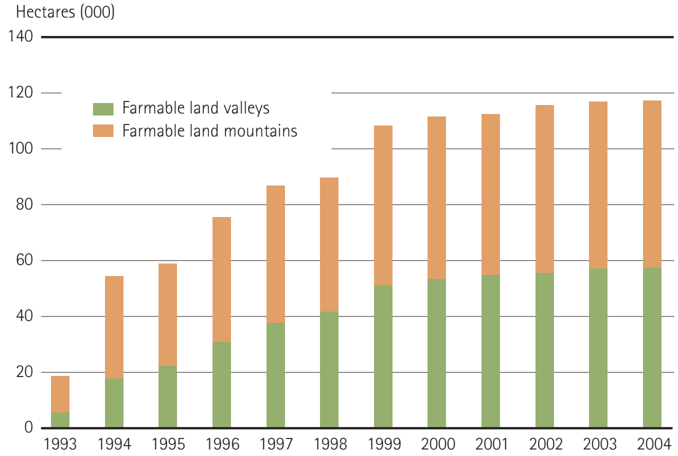
Source: SFSO

Figure 5: Trend in the ratio of labour income in farming families to comparable salaries outside the agricultural sector.



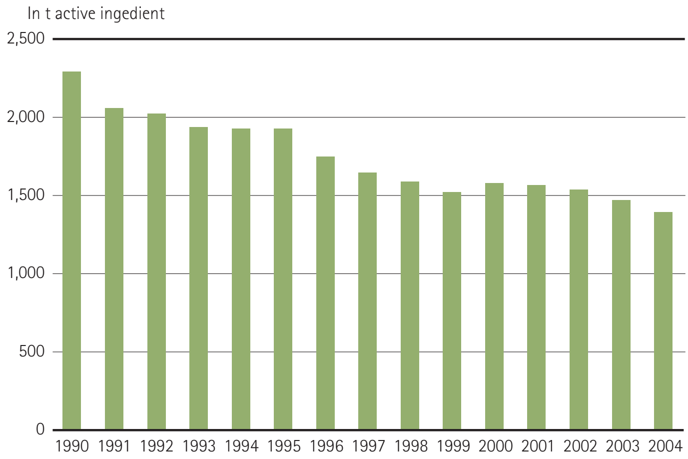
Source: Agroscope FAT Tänikon

Figure 6: Trend in ecological set-aside areas.



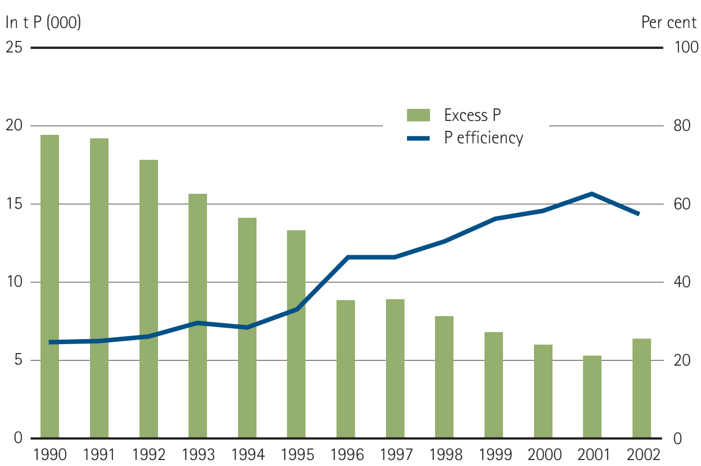
Source: FOAG

Figure 7: Trend in sales of plant protection products.



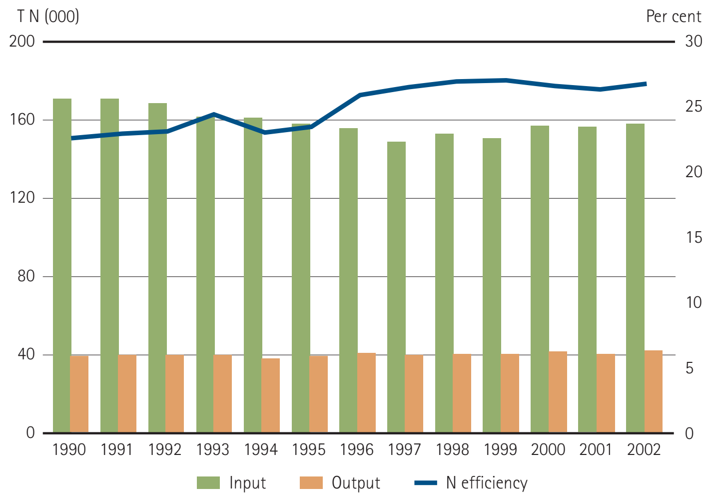
Source: Swiss Chemical Industry Association

Figure 8: Trend in excess phosphorus and phosphorus efficiency.



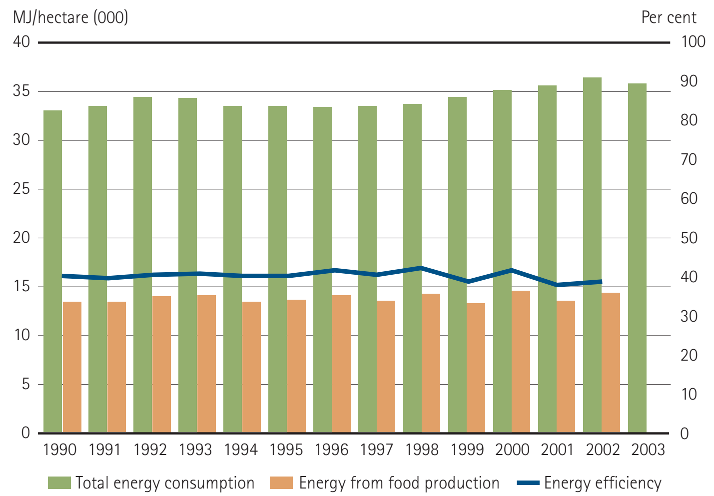
Source: Agroscope FAL Reckenholz

Figure 9: Trend in nitrogen input and output and nitrogen efficiency.



Source: Agroscope FAL Reckenholz

Figure 10: Trend in energy consumption, food calories produced and energy efficiency.



Source: SRVA

Using Agri-environmental Indicators to Support the Development of Agricultural Policy

The Canadian experience

Alexandre Lefebvre and Greg Strain[1]

A. LEFEBVRE – Agriculture and Agri-Food Canada, Ottawa, Canada.

G. STRAIN – Agriculture and Agri-Food Canada, Ottawa, Canada.

1 Adapted from: Lefebvre, 2005; Eilers, 2005; Junkins, 2005; McRae *et al*., 2004.

Abstract

Farmers, governments and other stakeholders in Canada's agricultural industry have become increasingly aware of the need to integrate environmental factors into their decision-making processes. Decision-makers at all levels share a common need for objective information on the current environmental performance of the agricultural sector, to determine whether this performance is satisfactory and how it is likely to behave in response to the decisions they make.

Agriculture and Agri-Food Canada (AAFC) has developed a set of agri-environmental indicators (AEIs) specific to the agriculture and agri-food sector to assess how well agriculture and agri-food systems manage and conserve natural resources and how compatible they are with the natural systems and processes in the broader environment. These AEIs are a practical means of assessing environmental sustainability by combining current scientific knowledge and understanding with available information on resources and agricultural practices.

Understanding, and communicating how changes to agricultural policies and programs will impact the sector's future economic and environmental outcomes is critical for the policy development and evaluation process. Achieving this insight necessitates linking science to analytical policy tools. Agriculture and Agri-Food Canada has used a multi-disciplinary approach to develop an integrated modelling capacity by linking a policy model, the Canadian Regional Agricultural Model (CRAM), to agri-environmental indicators. In recent years, this science-based analytical approach has proven very useful for agricultural policy analysis, for example to assess possible greenhouse gas (GHG) mitigation strategies and to support the selection of quantitative environmental performance targets for a major federal/provincial agreement.

Keywords: Agriculture and Agri-Food Canada, agri-environmental indicators, environmental performance, reporting, integrated modelling, Canadian Regional Agricultural Model, environmental sustainability, analytical policy tools.

1. Introduction

The agriculture and agri-food industry has a close connection with the environment, and environmental issues are not new to the sector. Canadians generally appreciate the environmental benefits that agriculture provides, including wildlife habitat, beautiful landscapes and natural processes such as nutrient cycling and water storage and filtering. Growing global demand for agricultural products and the desire to increase the country's share of these global markets has spurred significant changes in Canada's agricultural industry. New production technologies have been adopted and there has been a gradual shift towards larger, more intensified operations. Questions have been raised about the long-term sustainability of these production systems and their potential environmental costs. Issues such as water quality, wildlife habitat, biodiversity and greenhouse gas emissions are driving forces for all sectors of agricultural production to maintain acceptable levels of environmental stewardship. In some cases, heightened public concern now poses a direct constraint to agricultural growth. Similar concerns of greater numbers of global consumers are expected to increasingly affect the sector's ability to retain and compete for international markets.

Consequently, agriculture today must balance a wide and continually evolving array of demands and environmental challenges. Governments, farmers and other stakeholders are working together to promote research, programming and related actions to address environmental concerns. The initial focus on conserving the natural resource base upon which agriculture depends—particularly soil, water and genetic resources for crops and livestock—has broadened to include other priority areas such as the impact of pesticides and fertilizers, the potential entry of pathogens into water, the release of particulate matter, odours and greenhouse gases, wildlife habitat availability and the conservation of species at risk. Achieving the goal of long-term environmental sustainability in the agriculture and agri-food sector has become a more pressing and increasingly complex challenge.

2. Information for decision-making: The role of indicators

The individual decisions of agricultural producers have a direct influence on environmental sustainability. These decisions are influenced from beyond the farm gate by a variety of factors and stakeholders. Governments influence decisions through the development of agricultural policies and programs; researchers develop new technologies for improved productivity and sustainability; and consumers influence the marketplace through their purchasing choices. Farmers, governments, researchers, environmentalists, processors and consumers are all concerned about ensuring the sustainability of Canada's agriculture industry and each of these different groups can influence the outcome of this undertaking in unique ways. However, they all share a common need for environmental information. Decision-makers at all levels need objective, reliable and understandable information on the current and expected future evolution of environmental performance in the agricultural sector. They need to know whether current performance is satisfactory and how it is likely to behave in response to the decisions they make. Given this type of information, decision-makers are likely to have a better understanding of the pressures they face and of the needs and opportunities to change the system. The ability to communicate complex ideas in a clear and simple fashion is critical.

Historically, governments and all sectors of economic activity have invested considerable resources in promoting economic development and the use of systematic approaches and indicators to measure economic performance. These approaches have however, largely ignored environmental impacts, and the most commonly used economic indicators do not consider changes in the value of environmental assets and services. As a result, decision-makers who rely solely on such indicators run the risk of achieving economic goals at the expense of the environment and other objectives.

2.1. The NAHARP program

In 1993, in response to the need for agri-environmental information and to assess the impacts of agricultural policies on the environment, Agriculture and Agri-Food Canada began to develop a set of science-based environmental indicators specific to the agriculture and agri-food sector. In recognition of the continuing need for this kind of information, in 2003 AAFC established the National Agri-Environmental Health Analysis and Reporting Program (NAHARP). Its purpose is to strengthen departmental capacity to develop and continuously enhance Agri-Environmental Indicators (AEIs) and tools to integrate these indicators with economic and social information to assist policy development. The program uses three complementary approaches:

1. Update the existing set of AEIs by enhancing methodologies and underlying data when appropriate and possible, and developing new indicators to address key gaps in environmental information.

2. Improve the quality and reliability of tools that integrate agri-environmental indicators with economic information. This integrated economic/environmental modelling provides an improved predictive capacity for testing scenarios, for example, to better understand how changes to agricultural policies and programs may affect the sector's future environmental performance.

3. Develop the capacity to quantify the economic costs and benefits of environmental impacts in agriculture, for both farmers and society.

The results from Agriculture and Agri-Food Canada's work is published in the *Agri-Environmental Indicators Report Series*. A first report was published in 2000 (McRae *et al*., 2000), and a second report in 2005 (Lefebvre *et al*., 2005).

2.2. International collaboration

Agriculture is linked to many global environmental issues, and agricultural products are a key element of global trade. Consequently, several international agencies are also working to develop and use environmental indicators for agriculture. Internationally comparable indicators are needed to better understand the health of the global environment, to guide and evaluate international efforts to reduce environmental stresses and to help ensure that countries do not distort global markets and enhance their competitiveness at the expense of the environment. One international organization in particular, the Organisation for Economic Co-operation and Development (OECD), is coordinating efforts among its member countries to develop a set of agri-environmental indicators that are based on consistent and compatible methodologies (OECD, 2001). The development of environmental indicators at the international level is especially challenging because of differences in environmental conditions, economic activity, national priorities and the availability of data across countries. Through AAFC's work on agri-environmental indicators, Canada actively contributes to OECD efforts and benefits from the ongoing cooperation and exchange of results with other member countries also working on the development of these indicators.

3. Agri-environmental indicators

Agri-environmental indicators are a practical means of assessing environmental sustainability by combining scientific knowledge and understanding with available information on resource use and agricultural practices. To ensure credibility and rigour in this assessment process, all of our agri-environmental indicators have to meet a set of fundamental criteria. They have to be:

- *policy relevant:* indicators should relate to the key environmental issues that governments and other stakeholders in the agriculture sector are seeking to address;
- *scientifically sound:* indicators should rely on methodologies that are scientifically sound, reproducible, defensible and accepted, recognizing that their development may involve successive stages of improvement;
- *understandable:* the significance of the indicator values that are reported should be readily understood by policy-makers and the wider public;
- *capable of identifying geospatial and temporal change:* indicators should allow spatial and temporal trends to be identified; and
- *feasible:* indicators should make use of existing data as much as possible and they should not be prohibitively expensive to develop.

To identify and develop appropriate indicators of environmental sustainability in agriculture, a conceptual framework called the "Pressure–Outcome–Response Framework," was used. It considers three broad areas that, when applied to agri-environmental sustainability, can be described as follows:

- *Pressure:* environmental stresses that may influence important aspects of agricultural production, such as the selection of crops and management practices used for production;
- *Outcome:* ultimate impact of agricultural production on the health of the environment (soil, air, water, biodiversity); and
- *Response:* implementation by producers of key management options which influence the impact of agriculture on the environment.

While this framework provides a context for individual indicators, agricultural production and its interactions and linkages with the environment are complex and multi-faceted. Additional (non-environmental) pressures or responses such as markets, government policies and private expenditure, also influence the sector's environmental performance.

3.1. Calculation method

The agri-environmental indicators developed by Agriculture and Agri-Food Canada are designed to be responsive to changes in land use and farm management practices; to lend themselves to broad spatial scales; and to identify the sector's impacts on the environment. They typically fall into one of three categories:

- *risk indicators:* estimate of the likelihood of a potential environmental impact;
- *state indicators:* estimate of the actual presence and degree of an impact; and
- *eco-efficiency indicators:* estimate of resource-use efficiency, typically by comparing inputs and outputs of some material.

Agri-environmental indicators are calculated using models that integrate biophysical information on soil, climate and landscape, with land-use and farm management data generalized to portray an environmental condition on the landscape at a given time. These mathematical models and formulas have been adapted or developed on the basis of current scientific understanding of the interactions between various aspects of agricultural practices and the environment. This approach was selected instead of, for example, detailed environmental monitoring, because it lends itself well to calculations at broad spatial scales, it can isolate the specific impact of agriculture on the environment, it eliminates the time lag between land-use or management change and actual measurable impact, and it is compatible with forward-looking integrated economic/environmental models used for policy analysis.

3.2. Geospatial framework

Indicators are designed to estimate changes and trends in time and space. Most indicators use a suite of data that are collected at various temporal and geographical scales. A great deal of effort goes into developing proper ways of interpreting and integrating these data in a common geospatial framework to allow indicator calculation.

The spatial basis—or the areas used for most of the indicator-model calculations used by Agriculture and Agri-Food Canada—are polygons of the Soil Landscapes of Canada (SLC) map series. These maps portray generalized soil and landscape information at a scale of 1:1 million and are integrated into the National Ecological Framework for Canada (Ecological Stratification Working Group, 1995). Polygon size varies, ranging from about 10,000 ha to 1 million ha. Using these mapping units allows soil and landscape data to be integrated with farm management data for indicator calculations. Results can then be rolled up and reported at larger scales suitable for a national assessment.

Figure 1: Extent of agricultural areas covered by agri-environmental indicators.

Land use and farm management data are obtained from the Census of Agriculture, a survey by the Government of Canada, which is conducted every five years. Data from the Census is reallocated to the SLC polygon basis and may be supplemented by other custom data sets from provincial agencies, the private sector, remote sensing etc. as is appropriate and available.

A common set of agricultural SLC polygons are used to calculate the agri-environmental indicators for Canada. In order to be included in the set, the polygons must have at least five per cent of their area reported as farmland. As a result of these requirements, many polygons in the fringe areas where agricultural activities are highly dispersed are excluded from the calculations. Figure 1 shows a map of the 2,780 polygons that met this requirement, defining the extent of the agricultural area (approximately 67.5 m ha) covered by our agri-environmental indicators.

3.3. Understanding results

We have attempted to develop a standard classification framework for all indicators (Table 1), which consists of a five-class rating system, in which each class has a general meaning in terms of environmental sustainability or a given implication from a policy perspective. The ideal approach for assessing the conditions and risks identified by the indicators is to compare the results with science-based reference thresholds (such as environmental quality standards). However, thresholds that would allow us to differentiate between the five classes are typically not available, and most of the indicator classes were established on the basis of expert knowledge, an approach that is subject to additional interpretation. AAFC is currently working in partnership with Environment Canada to develop a systematic approach to establishing reference thresholds.

Map presentations of indicator results are used to provide the condition for a given indicator in a given year. In these map presentations, entire SLCs or other spatial polygons are assigned a value that applies to the agricultural portion of these polygons.

Within each area there are, undoubtedly, zones of greater and lesser concern that the indicator averages out to a single value. The aggregated result may obscure the local reality, and because of this, as well as the various limitations described above, the indicators cannot be interpreted as showing any specific on-site conditions (such as on an individual farm). The trends in an indicator over time are just as important as the current condition or status of the indicators. This aspect is generally presented in tabular format, setting out actual results for Canada and individual provinces.

The indicators are sensitive to changing farm management practices and are able to show patterns of environmental risk and conditions that reflect the intensity of agricultural production in regions across Canada. They provide a trend line over time that indicates whether the agriculture sector is moving towards or away from environmental sustainability. In this regard, they can be used to point out areas in which further research and investigation are required before actions can be taken, and provide useful additional information to decision-makers for developing and evaluating agricultural policy. The agriculture sector's interactions with the environment are, however, complex, and caution must be exercised in seeking overall interpretations from the trends observed in individual indicators. Positive trends in one indicator may lead to negative trends in another.

Table 1: Description of indicator classes for risk indicators.

Classes	Meaning	Implication
1 - Very low risk	In general this level of risk is **negligible**. Agri-environmental health is likely to be maintained or enhanced over time.	A more detailed analysis of the situation is warranted to understand the various factors that have contributed to this rating. Potential exists to export policy/program approaches to areas of higher risk.
2 - Low risk	In many cases this level of risk may be **acceptable**. Agri-environmental health is at low risk of being significantly degraded.	Continued adoption of beneficial management practices to better match the limitations of the biophysical resources may improve sustainability. Specific actions not necessarily warranted.
3 - Moderate risk	**Awareness** of the situation is important. Agri-environmental health is at moderate risk of being significantly degraded.	The trend towards or away from sustainability needs to be assessed. More attention should be directed locally to promoting the adoption of beneficial management practices in order to better match the limitations of the biophysical resources.
4 - High risk	Heightened **concern** is warranted. Under high risk conditions, agri-environmental health is at high risk of being significantly degraded.	A more thorough local assessment is probably warranted. Additional efforts and targeted actions are likely needed locally to better match practices to the limitations of the biophysical resources.
5 - Very high risk	**Immediate attention** is likely required. Under very high risk conditions, agri-environmental health is at very high risk of being significantly degraded.	A more thorough local assessment is warranted. Concrete and targeted actions are likely needed locally to better match practices to the limitations of the biophysical resources. It may be necessary to consider alternate land uses to reduce the risk.

4. Linking agri-environmental indicator models to policy models

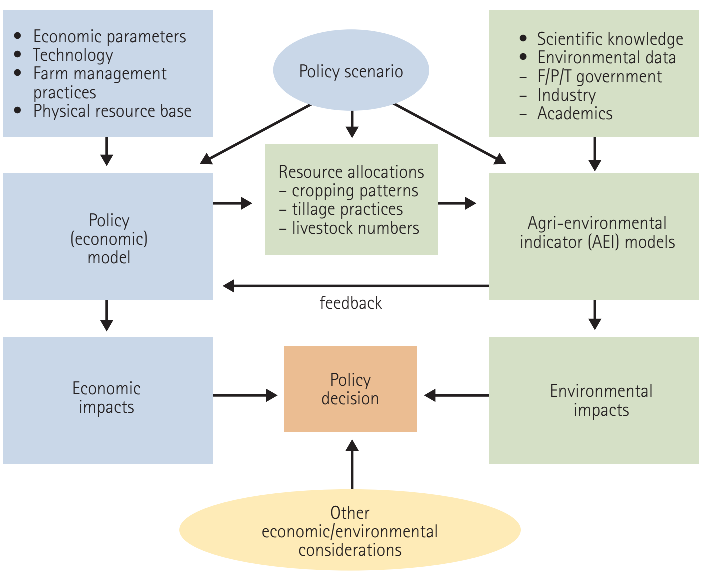
Agri-environmental indicators (AEI) provide a historical perspective on the agriculture sector's environmental performance. However, in order for the sector to manage its natural resources in a manner that is environmentally, socially and economically sustainable, there is a need to understand how changes to agricultural polices and programs will affect the sector's economic and environmental outcomes and how to produce outcomes that are consistent with government goals and objectives. Science must be harnessed in the policy development process to generate reliable quantitative information about environmental effects and support analytical tools that allow this information to be integrated into the policy decision-making process. In the present context, this involves integrating agri-environmental indicator models with policy models. Such integrated models can then be used to evaluate existing policies and programs relative to their combined economic and environmental performance, as well as to estimate or predict the economic and environmental impacts of proposed programs and policies.

Building this type of integrated modelling capacity requires a multi-disciplinary approach involving both research scientists and economists. The integrated economic/environ-mental modelling system under development at AAFC uses a policy model to estimate changes in farm resource allocations (crops and livestock) relative to a baseline level for selected scenarios. This information is then fed into AEI models to assess a suite of potential environmental outcomes (Figure 2). The economic model used is the Canadian Regional Agricultural Model (CRAM) (Horner *et al*., 1992). It is capable of estimating the change in resource allocations for various crop and livestock activities in response to changes in technology, government programs and policies or market conditions.

This integrated economic/environmental modelling approach was used extensively in the context of analyzing possible strategies in the development of greenhouse gas (GHG) mitigation programs for agriculture (Kulshreshtha *et al*., 2002; National Climate Change Secretariat-Agriculture and Agri-Food Table, 2000). Results from this integrated economic/environmental analysis of GHG mitigation options for agriculture were actually instrumental in getting agricultural soil sinks accepted under the Kyoto Protocol.

More recently, a study was initiated to support the selection of quantitative provincial environmental outcome goals and targets under a joint initiative of Canada's federal, provincial and territorial governments, the Agricultural Policy Framework (APF) (Heigh *et al*. 2005). Through it, ministers of agriculture pledged to meet the sector's challenges by jointly developing "an agriculture policy that is comprehensive, integrated and ensures that farmers have the tools to address issues, be competitive and capture opportunities in the areas of science, food safety and environmental stewardship." Ministers requested that development of the new policy follow certain principles, including the identification of common (i.e., Canada-wide) goals to secure the benefits of a consistent approach, and a commitment to report on progress in a consistent fashion across Canada. In the case of the environment, ministers also requested that indicators and targets be included.

Figure 2: Integrated economic/environmental analysis.



4.1. Using indicators to help set policy targets

The specification of common (i.e., Canada-wide) and measurable goals and targets for the APF was possible due to work previously completed on agri-environmental indicators and economic-environmental models. Essentially, the goals and targets selected were defined in a manner consistent with the definitions of the indicators themselves so that, in effect, the question for policy-makers became how far to "push" the indicators, in which direction and over what time period, and using which policy instruments?

The challenge for governments was to set targets that represented meaningful environmental gains and were feasible to achieve (by 2008), with known technologies, and at acceptable costs to producers and/or the public. To help meet this challenge, AAFC began its analysis by consulting with scientists and analysts to select various farming practices related to nutrient management, soil management, grazing management, livestock feeding management and agro-forestry. Eight scenarios of environmentally beneficial management practices (BMPs) were chosen:

- nutrient management: better matching of nitrogen to crop requirements;
- increased use of zero tillage;
- decreased use of summer fallow;
- permanent soil cover (e.g., forage crops, pasture);
- increased forage in crop rotations;
- grazing management: complementary and rotational grazing;
- combined feeding strategies; and
- agro-forestry: increasing plantations on agricultural lands.

Three different adoption rates for each of these practices were used to provide a range of impacts depending on the level of effort employed. Low effort assumes a moderate level of adoption of BMPs; medium assumes an intermediate adoption level; and high assumes an ambitious level of adoption. All adoption levels were technically feasible and were established using expert opinion. Obviously, the ambitious level provides the greatest environmental benefits, but is the most costly to implement.

The BMP's outlined above were imputed into CRAM to determine the impact on land-use and livestock production activities. For example, the adoption of permanent cover beyond a baseline or business-as-usual level (BAU) was imputed into the CRAM model. On a national scale, medium adoption rates for the permanent cover scenario assume the conversion of 600,000 hectares of land from cropland and summer fallow to hayland and tame pasture. The resulting impact on land-use and livestock numbers was a 2 per cent decrease in land area for crops and summer fallow, and a 1 per cent and 11 per cent increase in land use for hay and tame pasture production respectively. Cattle numbers increased by two per cent due to the increase in hay and tame pasture. The change in land-use and livestock production was then imputed into the various AEI models to obtain the associated impact on air, soil, water and biodiversity. For example, the impact of increased permanent cover on the Wildlife Habitat Availability on Farmland Indicator was approximately two per cent.

Analytical results were generated for Canada and all provinces for selected environmental indicators for the following periods:

- 1996 and 2001 baseline years, to provide policy-makers with an indication of recent environmental conditions and trends;
- a 2008 business-as-usual (BAU) baseline, which provides an estimate of expected environmental outcomes, based on projected economic growth and assumptions about anticipated uptake of specified farming practices in the absence of additional APF environmental programs; and
- potential environmental outcome targets for 2008, set in relation to the 2008 BAU baseline and based on additional adoption of BMPs.

Results from this analysis provide policy-makers with information on what levels of environmental improvements are feasible to obtain, and contributes options regarding target levels to negotiate in the APF's Implementation Agreements.

5. Lessons learned and future work

Agriculture and Agri-food Canada's experience over the past decade in developing and using national agri-environmental indicators and economic-environmental modelling systems for policy purposes has yielded valuable insights into the benefits of the approach:

- *Indicators* facilitate the inclusion of measurable environmental goals and targets in policies, and provide a means of evaluating their effectiveness and reporting progress. They can also help target policy implementation in areas and relative to environmental issues most in need of attention, particularly if they are amenable to geographic scaling at multiple scales;

- *Integrated economic-environmental analysis* can help estimate alternative policy outcomes and levels of effort needed to achieve these, and provide information for setting meaningful and achievable targets. To be useful for this purpose, indicators must be amenable to modelling; and
- *Indicators and modelling systems* must be based on sound science, adequate and valid data, and be accepted by stakeholders. This requires a long-term institutional commitment to their use and ongoing improvement, such as investments in research, data collection and interaction with users and consumers of the results (policy-makers, representatives in industry, environmental groups, etc.).

Experience to date has also shed light on limitations to the work, of which the following are key examples:

- *uncertainty* regarding the precision or accuracy of indicator model estimates, particularly when scaling-up results over large areas;
- *limitations* concerning the scope of agricultural practices captured by indicator models (some indicators and models are not currently sensitive to key practices, such as manure management);
- *inadequate coverage* of some issues by existing indicators;
- *inconsistency* between the spatial basis of indicator models and economic models, which currently precludes setting environmental targets at sub-provincial levels; and
- *limited ability* to estimate the economic costs and benefits of adopting management practices for achieving alternative levels of environmental targets, which makes it difficult to design economically efficient policies.

5.1. Future work

Work will continue at Agriculture and Agri-Food Canada through the National Agri-Environmental Health Analysis and Reporting Program (NAHARP), to improve the indicators and modelling capacity described in this paper, and to apply the work to policy development, performance monitoring, program evaluation and public reporting. Improvements will focus on three particular areas:

- work to enhance the methodology and data of existing indicators where necessary, and to develop new indicators to address key gaps;
- work to improve economic models and their linkages with environmental indicator models; and
- work to develop a capacity to understand and quantify the economic costs and benefits of environmental changes due to agriculture.

AAFC will continue its work to develop policy in priority areas important to sustainable development in agriculture (such as climate change policy). Public reporting of agriculture's environmental performance will also continue to be a priority for the department.

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Agri-environmental Indicators and Policies: An OECD perspective

Wilfrid Legg[1]

W. LEGG – Agricultural Policies and Environment Division, Trade and Agriculture Directorate, Organisation for Economic Co-operation and Development, 2 rue André-Pascal, 75775 Paris Cedex 16, Paris, France.

1 This paper has benefited from comments on an earlier draft by colleagues in OECD but the author remains responsible for any remaining errors. The paper does not necessarily reflect the views of the OECD or its Member countries.

Abstract

This paper discusses the evolution of developing agri-environmental indicators (AEIs) in the OECD; the changing agri-environmental policy environment; and some thoughts on how AEIs might change as a result. Through the development of AEIs, OECD provides a tool to assist policy-makers in the design, monitoring and evaluation of policies. A Driving Force–State–Response framework is used to organize the AEIs, and indicator selection is based on policy relevance, analytical soundness, measurability and ease of interpretation. Environmental performance is a high societal and policy priority, because markets to improve environmental performance are often lacking or poorly functioning. However, only a small part of support to the agricultural sector is directly targeted for environmental purposes. Currently, agri-environmental policy tends to focus on constraints on inputs used or practices adopted, with less of an emphasis on direct support for environmental performance in terms of outcomes. In a number of key areas, greater efforts are needed to develop AEIs related to water use and quality, biodiversity and farm management practices. Increasing the suitability of AEIs for policy needs and analytical efforts, and better integration and consistency across spatial scales, are also required. Networks among multiple stakeholders are a relevant means to further the development of policy-relevant indicators.

Keywords: Agri-environment, indicators, OECD, support, policy, monitoring, evaluation, driving force-state-response framework.

Introduction

Governments in OECD—and several non-OECD—countries have been increasingly interested in tracking the environmental performance of agriculture, identifying possible future environmental problems associated with agricultural activities, and trying to better understand the effects of different agricultural policy measures on the environment. More recently, there is heightened concern over the effect of external environmental events—in particular climate change and variability risks—on the agricultural sector.

Agriculture exerts a major influence on the environment. Overall, across the OECD area, agriculture uses roughly 40 per cent of available land and 45 per cent of water resources. It is a major source of water pollution from nutrient and pesticide run-off. It has a significant impact on biodiversity and shapes the landscape. It creates greenhouse gas emissions but also acts as a carbon sink. In short, agriculture has a complex relationship with the environment as user and polluter of natural resources, and as provider of ecosystem and cultural landscapes.

Agriculture is a sector in which policy plays a significant role in most OECD countries. Agricultural policies provide monetary transfers that influence—directly or indirectly—what and how much to produce and where and under what conditions. Environmental regulations require farmers—either at their own cost or with the aid of subsidies—to adopt certain practices or deliver particular outcomes determined by governments. The overall set of policies leads to a complex web of incentives and disincentives facing farmers, with an equally complex set of multiple environmental effects.

This paper examines the evolution of agri-environmental indicators (AEI), what has been accomplished to date on developing AEIs, the changing agri-environmental policy environment, and some thoughts on how AEIs might adapt to that changing policy environment in the future.

Evolution of agri-environmental indicators

OECD work on developing agri-environmental indicators (AEIs) has been underway since 1993. It has involved several expert meetings and workshops, engaged a wide range of expertise, and resulted in four major publications. The main objective has been to provide a tool to assist policy-makers in the design, monitoring and evaluation of policies. More specifically, the work:

- describes the current state and trends of environmental conditions in agriculture that may require policy responses (i.e., establishing baseline information for policy analysis);
- highlights where "hot spots" or new challenges are emerging;
- provides a tool to better explain the cause and effect of changes in the environmental conditions of agriculture, especially the role that policy has to play relative to other drivers in agricultural systems, such as changes in technology and consumer preferences;
- compares trends in performance across time and between countries, especially to assist policy-makers in meeting environmental targets, threshold levels and standards where these have been established by governments or international agreements; and
- uses indicators in modelling policy scenarios (e.g., the environmental effects of different policy instruments and mixes), and projecting future trends.

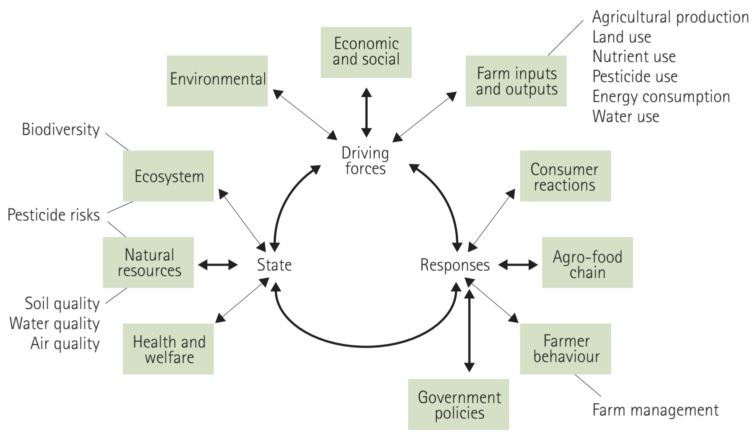
The OECD set of AEIs, which are part of a broader national and international effort to develop indicators, can help in answering a broad range of policy questions, including:

- What is the impact of agriculture on the environment, so that policy-makers can target the most important impacts?
- What are the environmental impacts of changing support to the agriculture sector?
- What are the environmental impacts of different agricultural policy instruments, such as price support, area or headage payments, or direct income payments?
- What might be the environmental impacts of extending current policies and farming practices into the future?
- What are the economic implications for the agricultural sector of meeting environmental targets, such as those set out in international agreements?

The OECD's Driving Force-State-Response (DSR) model is the organizing framework for the work report (Figure 1). There are a wide range of economic, social and environmental factors that determine the environmental outcomes from farming, as illustrated by the DSR model. The OECD works seeks to explore the environmental pathways outlined in the DSR model across OECD countries over the period 1990–2004 for primary agriculture.

Not all the DSR pathways identified in Figure 1 are covered in the OECD work. In particular, the impact of policies, market developments and structural changes on the environmental performance of agriculture are outside the scope of OECD work. Moreover, the work does not examine the impacts of changes in environmental conditions on agriculture (e.g., native and non-native wild species, droughts and floods, climate change); the impact of genetically modified organisms on the environment; or the impact of using farm chemicals on human health and welfare. For full coverage of the development of OECD work on AEIs, readers should refer to the publications starting in 1997, which include concepts behind the indicators and details of the DSR framework.

Figure 1: The driving force-state-response framework: Coverage of indicators.



Source: Adapted from OECD (1997)

Data and information sources

OECD AEIs work is mainly being developed with the following data/ country information, and using the following indicator methodologies:

- OECD member country responses through questionnaires;
- expert meetings hosted by OECD member countries on specific agri-environmental indicator areas, which provide guidance for the selection and definition of indicators as well as detailed data and information from country case studies (Box 1);
- OECD regular work on collecting environmental data, and the development of pesticide risk indicators in the OECD Working Group on Pesticides;
- information and data obtained from external sources, in particular international governmental organizations—such as FAO and Eurostat—international environmental agreements—such as Kyoto, Gothenburg and the Montreal Protocols—and non-governmental organizations—such as Birdlife International; and
- reviews of literature, databases and websites, especially for country information on the environmental performance.

Box 1: OECD expert meetings on agri-environmental indicators: 2001–2004

- *Agriculture and Biodiversity: Developing Indicators for Policy Analysis*. Swiss Federal Research Station for Agroecology and Agriculture, Zurich-Reckenholtz, Switzerland, November, 2001.
- *Agricultural Impacts on Landscapes: Developing Indicators for Policy Analysis*. Norwegian Institute of Land Inventory (NIJOS) on behalf of the Norwegian Ministry of Agriculture, Oslo, Norway, October, 2002.
- *Soil Organic Carbon and Agriculture: Developing Indicators for Policy Analyses*. Agriculture and Agri-Food Canada, Ottawa, Canada, October, 2002.

- *Agricultural Impacts on Soil Erosion and Soil Biodiversity: Developing Indicators for Policy Analysis*. Italian Ministry of Agricultural and Forestry Policies, the Ministry for the Environment and Territory, and the National Institute of Agricultural Economics, Rome, Italy, March, 2003.
- *Agriculture and Land Conservation: Developing Indicators for Policy Analysis*. Japanese Ministry of Agriculture, Forestry and Fisheries, Kyoto, Japan, May, 2003.
- *Agricultural Impacts on Water Use and Water Quality: Developing Indicators for Policy Analysis*. Korean Republic Ministry of Agriculture and Forestry and Korean Rural Development Administration, Gyeongju, the Republic of Korea, October, 2003.
- *Farm Management and the Environment: Developing Indicators for Policy Analysis*. New Zealand Ministry of Agriculture and Forestry, Palmerston, North, New Zealand, March, 2004.

Source: The Proceedings of these Expert Meetings can be freely downloaded from the OECD Web site at: www.oecd.org/agr/env/indicators.htm.

Recent progress in developing agri-environmental indicators

OECD work on AEIs has led to considerable progress in both the identification and specification of the characteristics of policy-relevant indicators. It has also calculated indicators in a number of areas, which now have gained an international reputation as providing a benchmark in environmental monitoring for the agricultural sector. In particular, progress has been made in developing AEIs against general OECD criteria of:

- *policy relevance* – addressing the main environmental issues faced by most or a representative group of OECD countries in the agriculture sector, while recognizing that some issues are policy relevant for some countries;
- *analytical soundness* – consistent with the best available scientific knowledge, while recognizing that this is constantly evolving;

- *measurability* – cost-effective availability of current or planned data for which methodologies are well-established; and,
- *ease of interpretation* – so the indicators communicate essential information to policy-makers and the wider public in ways that are unambiguous and easy to understand.

Limitations

The indicators developed by the OECD provide a basis upon which policy-makers can obtain an overall view of trends that may require action and act as a tool for monitoring and analyzing the impact of agricultural activities and policies on the environment. However, the indicators should be interpreted and used with caution for the reasons given below:

- *Definitions and methodologies for calculating indicators* are standardized in most cases but not all, such as for biodiversity and farm management. Moreover, for some indicators, such as greenhouse gas emissions (GHGs), work towards their further improvement is ongoing (e.g., by incorporating agricultural carbon sequestration into a net GHG balance);
- *Data quality and comparability* are as far as possible consistent and harmonized across the various indicators, but deficiencies remain such as the absence of data series (e.g., pesticide risks, biodiversity), variability in data coverage (e.g., pesticide use and energy consumption), and differences related to how the data were collected (e.g., surveys for farm management, census for land use, and models for water use);
- *Spatial aggregation* of indicators is given at the national level. However, for certain indicators (e.g., water quality) this can mask significant variations at the regional level—although where available, the report provides information on regionally disaggregated data;
- *Trends and ranges in indicators*—rather than absolute levels—are important for comparative purposes across countries for many indicator areas, especially as local site-specific conditions can vary considerably within and across countries. But absolute levels are of significance where: limits are defined by governments on the basis of scientific evidence (e.g., nitrates in water); targets agreed under national and international agreements

(e.g., ammonia emissions); or the contribution to global pollution is important (e.g., greenhouse gases);

- *Agriculture's contribution to specific environmental impacts* is sometimes difficult to isolate, especially for areas such as soil and water quality, where the impact of other economic activities is important (e.g., forestry) or the "natural" state of the environment itself contributes to pollutant loading (e.g., water may contain high levels of naturally occurring salts);
- *Environmental improvement or deterioration* is in most cases clearly revealed by the direction of change in the indicators (e.g., soil erosion, greenhouses gases). For some indicators, change can be ambiguous. For example, changes in farm practices, such as no or minimum till agriculture, can lower soil erosion rates. However, this may also result in an increase in the use of herbicides, which could potentially deteriorate adjacent aquatic ecosystems; and
- *Baselines, threshold levels or targets for indicators* are generally not used to assess indicator trends in the report as these may vary between countries and regions due to difference in environmental and climatic conditions, as well as national regulations. But for some indicators, threshold levels are used to assess indicator change (e.g., drinking water standards) or targets compared against indicators trends (e.g., ammonia emissions and methyl bromide use).

These limitations need to be viewed in a broader context, as in many cases they also apply to other indicators regularly used by policy-makers. For example, there can be wide variations around national averages of socio-economic indicators (e.g., employment); and methodological and data-deficiency problems are not uncommon (e.g., wealth distribution). Work on establishing agri-environmental indicators is relatively recent compared with the much longer history of developing economic indicators, such as gross domestic product. Measuring the linkages between the biophysical environment and human activities through indicators is often more complex than monitoring trends in socio-economic phenomena, given that many agri-environmental effects are not valued in markets, nor easily measured in physical terms (e.g., biodiversity).

The latest OECD-wide evidence on the environmental performance of agriculture is available in the publication *The Environmental Performance of Agriculture* (OECD, forthcoming September 2007), and is summarized below:

Box 2: Summary of latest trends in the environmental performance of agriculture

- Driving forces:
  - *Inputs*. In OECD countries over the past 10 years, fertilizer (-2 per cent) and pesticide use has declined (-8 per cent). However, water use has increased (three per cent), as has on-farm energy use (six per cent). With farm production increasing more rapidly than the use of most inputs, it appears that input efficiency has improved and, as a consequence, pressure on the environment in some cases may have been eased.
  - *Policies*. Support to OECD farmers (as measured by the OECD Producer Support Estimate indicator) currently accounts for about 30 per cent of total farm receipts, most of which is still linked to production. Production-linked support encourages the higher use of inputs. Maintenance of land in agriculture often increases pressure on the environment than would otherwise be the case in the absence of this form of support. But there has been a shift away from "production-linked" policies and greater use of measures intended to improve the environment. National and international environmental policies are also exerting a growing influence on the environmental impact of farming, especially concerning water quality and availability, ammonia emissions, climate change, and biodiversity.
  - *Agriculture's role in the economy*. From 1990 to 2003, the volume of agricultural production rose by three per cent, and further growth is projected over the next decade. With decreasing agricultural land area (-3 per cent) and employment (-10 per cent), higher productivity is being achieved by genetic improvements, better input management (nutrients, pesticides, water and energy), technological innovations and changes in farm structures.

- State of the environment:
  - *Nutrient surplus* (the balance between nitrogen and phosphorus inputs, largely fertilizers and livestock

manure, and outputs, mainly the uptake of nutrients by crops and pasture). Nutrient surplus has generally decreased, reducing environmental pressures on soil, water and air. Most of the countries that have recorded large decreases in nutrient surpluses, are, however, mainly those with the highest nutrient use, indicating there is still room for improvement. Rising or large nitrogen surpluses are commonly a result of the intensification of livestock production, since another surplus source, nitrogen fertilizer, is generally decreasing in most countries. Due to the accumulation of phosphorus in farmed soils and its slow transport time, concentrations in water could continue to rise, even while phosphorus surpluses are diminishing.

– *Pesticide use* (active ingredients). Although evidence on the environmental effects associated with pesticide use is not widely available across OECD countries, existing data suggest a link between a decrease (increase) in pesticide use and decreasing (increasing) harmful effects. Although pesticide use has increased in some countries, pesticides have changed over time and many of them are today less environmentally harmful. However, the persistence in the environment of some older pesticides (e.g., DDT atrazine and derivatives) remains a concern, although these products are now banned in some countries.
– *Energy*. Energy consumption on farms in OECD countries has increased by six per cent between 1990 and 2003 compared to an increase of 17 per cent recorded for other sectors. Energy consumption has grown at a higher rate than farm production, reflecting continued expansion of mechanization and increasing machinery power. Energy subsidies, mainly for on-farm fuel use, are widespread and a disincentive to reduce energy consumption and use energy resources more efficiently. Thus, the potential benefit of lowering greenhouse gas emissions is lowered.
– *Water use*. Agricultural use has grown more rapidly than for other users, mainly driven by a 6 per cent expansion in the area irrigated in some countries.

Over-exploitation of water resources in certain regions is damaging ecosystems by reducing water flows in rivers and wetlands. Groundwater use by irrigators is above recharge rates in some regions, which is also undermining the economic viability of farming in affected regions. Government support for irrigators is widespread and can aggravate the overuse of water and act as a disincentive to efficient water use. There is also a low uptake of water-efficient irrigation technologies and poor maintenance of irrigation infrastructure, which in turn leads to the waste of water across many OECD countries.

– *Soil erosion*. There has been a large reduction in areas of moderate to severe erosion risk. This is associated with the growing adoption of soil conservation practices, such as low or no soil tillage, the requirement in some OECD countries to maintain green cover during winter, and a reduction in cultivation of fragile soils. The costs associated with off-farm soil erosion are high in some regions, and involve treating drinking water, dredging rivers and improving aquatic ecosystems.
– *Water pollution*. Agricultural sources of pollution in OECD countries have on average declined slightly, linked to reductions in nutrient surplus and pesticide use. But absolute pollutant levels are significant in many regions, and in some regions, farming's share of nutrient-water pollution has risen, as other pollution sources have decreased more rapidly in other industries. The cost associated with treating drinking water to remove nutrients and pesticides and improve aquatic environments is significant in many countries.
– *Air pollution*. Pollutants from agriculture account for a relatively small share of total OECD acidifying emissions (25 per cent), use of ozone depleting substances (five per cent), and greenhouse gases (nine per cent). Agricultural ammonia emissions (from livestock and fertilizers) decreased by 35 per cent between 1990 and 2003, but less rapidly than acidifying emissions from other sources. Some countries will need to

reduce ammonia emissions to meet the 2010 targets agreed under the Gothenburg Protocol. OECD countries have met the 70 per cent reduction target for methyl bromide use between 1991 and 2003 under the Montreal Protocol, due to have been completely phased-out by 2005—which was, however, not achieved. Greenhouse gases from agriculture increased by one per cent from the Kyoto Protocol base period (1990–92), but at a lower rate of growth than for other sectors. Moreover, although information is currently limited, agriculture can also help to lower greenhouse gas emissions through increasing the soil carbon sink capacity of farmed soils, and expanding biomass supplies as a feedstock for renewable energy and raw material production.

  – *Biodiversity*. The genetic diversity of crop varieties and livestock breeds used in farming is increasing in certain OECD countries, probably due to farmers' business strategies associated with diversification, niche market development and agri-environmental policies. However, the extent to which this is improving the environmental resilience of farming systems and lowering disease risks is unclear. For many countries, farmland is a major primary habitat for flora and fauna, but species richness and abundance has declined. Farmland bird populations fell over the past decade, but in some countries populations have shown signs of recovery more recently. Adverse farm impacts on wild species are mainly due to deterioration in the quality of farmland habitats, nutrient and pesticide pollution, reduced water flows, the clearance of native vegetation and, in some areas, the conversion of farmland with a high nature value to other uses.

- Responses:
  – *Environmental farm management practices*. Increased uptake of these practices is the result of incentives provided through government payments and regulations, and voluntary private-led initiatives, often promoted by food processors and retailers or individual farmers and local markets. There are relatively higher

uptakes for environmental nutrient and soil management practices compared to those for pest, water and biodiversity management. Policies and private initiatives have led to the rapid expansion of certified organic farming in many countries, although by 2003 it accounted for less than two per cent of total OECD agricultural land area.

Evolution of the agri-environmental policy environment

All OECD countries share the goal of moving toward a path of long-term sustainability in which improving the environmental performance of agriculture has become a high policy priority. However, these intentions are not always matched by corresponding policy actions. The key challenge occurs because the environmental effects (externalities) of agriculture are not always reflected in market prices, and thus the market alone will not lead to an economically and environmentally efficient allocation of resources.

Output-linked support measures based on commodities produced or inputs used remain dominant and only a small share of support can be identified as directly targeted toward environmental improvement. Nevertheless, other payment programs are often conditional on: farmers adopting environmentally-friendly practices (cross-compliance); the availability of services provided to farmers with a high environmental content (such as research, education, training and information); and the subjugation of agriculture to environmental regulations (polluter pays principle) on, for example nutrient loading in water courses or pesticide residues in food. Although effective agri-environmental policies reduce environmental degradation and conserve natural resources, they can also alter relative prices and thus effect production and trade patterns.

At the risk of over-generalization, in the past agri-environmental policies in OECD European and Asian countries adopted policies that tended to give a high priority to enhancing or conserving environmental benefits provided on working farms, whereas those in the U.S. tended to give a high priority to reducing or containing environmental harm by idling sensitive agricultural land off working farms. Policies in Europe would be characterized as rewarding farmers for the benefits they provide to the environment in the process of using resources in farming; while in the U.S., policies would be characterized as rewarding farmers for the benefits they provide to the environment in the process of retiring resources from farming. In Australia and New Zealand, the tendency has been for agriculture to be subject to economy-wide regulations—with few specific measures for the agricultural sector alone. In all countries agriculture is expected to comply with broad environmental regulations—with greater or lesser applicability, partly dependant on property rights accorded to farmers—and varying degrees of enforcement to limit or reduce environmental harm.

In OECD European and Asian countries, support provided to producers from government policies is significantly higher than in the U.S., Canada and Australasia. But this is changing in terms of some apparent convergence of policy objectives, types of measures used and support provided—although not yet in overall levels of producer support as measured by the OECD's Producer Support Estimate (PSE).[2]

Types of agri-environmental programs in OECD countries[3]

Agri-environmental payments

Many OECD countries have made payments available to farmers, on a voluntary basis, to encourage them to implement more environmentally-friendly farming practices. In particular, the European Union, Norway,

2 The calculations of support to agriculture through measuring the Producer Support Estimates (PSE) that are undertaken by the OECD are the internationally recognized measures of transfers to agricultural producers arising from agricultural policies in OECD and selected non-OECD countries. The results are published annually in *Agricultural Policies in OECD Countries: Monitoring and Evaluation and in Agricultural Policies in Non-OECD Countries: Monitoring and Evaluation*, where further details of the concept and definitions may be found. In the 2007 report *Agricultural Policies in OECD Countries: Monitoring and Evaluation*, the classification of the categories of PSE policy measures changed to reflect the evolution of policies that are moving towards some de-linking of support from commodity production.

3 This updates material presented in *Agricultural Policies in OECD Countries—Monitoring and Evaluation 2003* and in *Inventory of Policy Measures Addressing Environmental Issues in Agriculture for selected countries*, which is available on the OECD Web site at: http://www.oecd.org/countrylist/0,2578,en_2649_33791_34691514_1_1_1_1,00.html.

Switzerland and the U.S. have substantially increased the use of agri-environmental payments. An expansion in these measures started in the mid-1980s and has continued. More recently, other countries, including Korea and Japan, have also begun to make greater use of these measures. Agri-environmental payments typically represent a modest, albeit rising, share of overall budgetary support to agriculture in these countries.

Many agri-environmental policy measures have been introduced in response to domestic, regional or local environmental issues. However, international pressures also look likely to continue to exert a growing influence over agri-environmental policy. These pressures include commitments relating to a range of international environmental agreements to address trans-boundary environmental issues, such the 1997 Kyoto Protocol, which specifies greenhouse gas (GHG) emission targets for 2008 to 2012, and the International Convention on Biological Diversity (CBD), which requires signatory countries to develop national strategies for conservation and biological diversity.

The diversity of programs across OECD countries and regions is vast. Some notable trends include payments to support the adoption and maintenance of low-intensity farming systems, particularly organic farming. Also common are land retirement payments to promote environmental objectives; payments linked to specific habitat or landscape management requirements; and transitional payments to assist farmers meeting the structural costs of complying with new environmental regulations. A range of payment programs has also emerged in some countries to address issues of climate change (for example, promoting the planting of shelterbelts for the sequestration of greenhouse gas emissions and biomass crops for bio energy production).

Payments are typically provided annually to farmers under fixed-term management agreements, with the amount paid being linked to the area of farmland covered, rather than specific environmental outcomes. The intention is generally to reimburse farmer compliance costs on the principle of profit forgone, sometimes with the addition of an incentive element. Some programs also include the provision of training and technical advice to assist farmers in carrying out targeted activities.

Many programs have attracted high rates of participation. For example, coverage under agri-environmental payment contracts reached almost 20 per cent of European Union farmland by the end of the 1990s. The growing prominence of these measures has invited increasing scrutiny. A number of studies point to evidence of environmental improvements generated by these programs. for example, they have been variously credited in Europe and the U.S. with reducing soil erosion, limiting pressures from input use, constraining pollution and overgrazing, and contributing to maintaining valued cultural landscapes and habitats.

Yet in certain cases significant shortcomings have also been identified in their design and implementation. For example, some payments have not been well-targeted and have been implemented without an overall evaluation of the associated costs in relation to the environmental benefits. For example, payments have been made available to farmers uniformly at a national level, yet the benefits have been concentrated locally or have been site-specific. Where payments have been implemented together with more production-linked support policies, they have been less effective at encouraging farming practices associated with countering environmental problems.

Organic agriculture is expanding in all OECD countries to meet increasing consumer demand, although it still only accounts for a relatively small share of agricultural production and food consumption. Organic agricultural practices are generally considered more environmentally friendly than conventional agriculture, particularly with regard to lower pesticide residues, a richer biodiversity and greater resilience to drought. Organic farming systems also hold the potential to lower nutrient run-off and reduce greenhouse gas emissions. However, there are situations where intensive management within organic farming regimes can impoverish biodiversity and animal manure can be applied in excess of requirements. More land may also be needed in some countries to produce a given level of output, land which has alternative value in terms of its potential use as, for example, a natural area, depending on its current and historical use.

Measures providing payments based on farming practices are prominent and include support to farmers adopting low-intensity farming systems, including organic production systems and other less input-intensive forms of production. Two types of payments can be distinguished that encourage organic farming: transitional per-hectare payment tailored to any income loss as a result of converting to organic production; and continuing payments based on area and headage to stimulate organic farming after the transition period. Such payments are particularly important in the European Union, Norway and Switzerland.

Coordination of policy approaches to organic agriculture, particularly when a number of different measures are being used, is reflected, for example, in the development of integrated action plans for organic farming. While organic producers can benefit from traditional agricultural support policies such as price support, such policies are likely to discourage the development of the organic sector. This is because such policies provide incentives to adopt farming practices that increase production (quantity) rather than those, like organics, which stress quality. Moves to reduce the dominance of these forms of support will be of benefit to organic producers and reduce the need for continual payments for organic production.

It has also been observed that some payments have ended up subsidizing basic environmental maintenance activities which, consistent with the polluter-pays-principle, should properly be carried out by farmers at their own expense. Payments in such cases tend to bestow a competitive advantage on the farmers who receive them, and thereby risk distorting agricultural production and trade.

A number of agri-environmental payment programs have been improved over time in the light of experience and improved information. For example, since 1990, enrolment in the major environmental land retirement payment program in the U.S.—the Conservation Reserve Program (CRP)—has been targeted according to the Environmental Benefits Index (EBI), which scores estimated environmental benefits relative to costs. Further improvements were made to this system in 1996. In 2004, the Conservation Security Program provided payments and technical assistance to promote conservation practices on farm land. The Environmental Quality Incentives Program (EQIP) was reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. The Environmental Quality Incentives Program provides incentive payments and cost-shares to implement conservation practices for both livestock and arable operations.

The European Union's agri-environmental payments are included in the "Second Pillar" of the Common Agricultural Policy (CAP), together with structural adjustment measures, less-favoured area payments and various rural development policies. Member States can choose among a long list of agri-environmental measures, selecting them based on their specific problems and priorities, as required, under the comprehensive monitoring and evaluation procedures for programs over the 2000 to 2006 period. Member States have recently produced a mid-term evaluation of these programs, which has been used to design the next generation of Second Pillar programs for 2007 to 2013. A minimum share of payments is now imposed on Axis 2 (land management), which includes mainly agri-environmental, animal welfare, Natura 2000, afforestation and less-favoured area payments.

Charges and taxes

There still appears to be only limited application of charges or taxes based on the environmental damage caused by agriculture, notwithstanding the endorsement by OECD countries of the polluter-pays-principle. This is in contrast with other sectors, where environmental taxes and charges are more common. The relatively rare application of pollution taxes in agriculture is commonly attributed to identification and measurement problems. Unlike a factory where pollution can normally be monitored at "point" sources, pollution from agriculture is often more dispersed, originating from many different farms and exhibiting varying intensities.

Nonetheless, some examples of these policy measures do exist. Since 1998, the Netherlands has tackled the measurement problem by introducing a range of levies on off-farm nutrient emissions above a set limit. Since 2006, the system directly regulates the maximum amount of fertilizers (animal manure pus maximum amounts of nitrate and phosphate) that may be used on the farm. The former system (MINAS) regulated emissions, not usage, to comply with the EU Nitrates Directive. More commonly, environmental taxes are applied on farm inputs. For example, various taxes and charges are currently levied on pesticides in Belgium, Denmark, Finland, Norway and Sweden, while fertilizer levies are applied in some OECD countries, including Sweden. Input-based taxes are generally inexpensive to administer, but may be less effective than a tax on pollution itself, as they do not discriminate on the basis of actual loading on the environment.

Tradable rights

Tradable rights based on environmental quotas, permits and restrictions also do not appear to play a significant role in agri-environmental policy, despite the growing use of such measures for environmental policy in other sectors (there is already experience with tradable CO_2 permits within the energy sector). However, in the past decade the Netherlands has implemented systems of tradable permits in relation to the volume of manure produced by farms.

There are also examples of tradable schemes that are applied across a number of sectors, including agriculture. These include tradable rights for the development of wetlands ("Wetland Mitigation Banks") in the U.S., and tradeable water extraction rights, which have been implemented on a state/regional basis in the U.S. and Australia. Australia is developing a more market-based system for water, including the introduction of water trading across state boundaries.

Regulatory requirements

Regulatory requirements play a role in addressing environmental issues in agriculture in all OECD countries. Some of these requirements are specific only to agriculture, while others are part of broader national environmental legislation affecting many sectors, including agriculture. Regulatory requirements tend to be less flexible than economic instruments, as they do not allow producers the freedom to determine for themselves the most appropriate ways of meeting environmental objectives. However, they also tend to minimize risk and uncertainty, and therefore constitute a vital element of environmental policy in most OECD countries, particularly with respect to acute environmental problems.

All OECD countries have applied legislative requirements to deal with problems relating to pollution, and the degradation and depletion of natural resources. The main categories of these requirements include: the availability of certain inputs to farmers, (for example, through the registration of pesticides and other agrochemicals); farm practices, (for example, the setting of limits on stock and the spreading of manure); and the application of mandatory procedures, (for example, planning or consent processes relating to land use, water extraction and the construction of livestock facilities). Regulatory requirements are also common to protect specific valuable wildlife and habitats, and to protect agriculture and the environment from damage from invasive species and new organisms.

Over the past two decades, there has been a trend towards more regulation and binding constraints, but not always uniformly across the whole sector—such as for large animal units in the U.S., but not small ones. A significant proportion of requirements imposed in OECD countries are applied at local and regional levels. For example, in the European Union, standards are developed at a range of levels, stretching from the Union itself down to individual regions in Member States. Regulatory requirements are often applied under the framework of over-arching legislation at the national, federal (or EU-wide) level; (for example, New Zealand's Resource Management Act (1991) tasks Regional Councils with the responsibility of environmental resource-use policy). However, while the EU Nitrate Directive, which sets a benchmark limit on nitrate levels associated with the application of manure in the European Union, it leaves Member States free to determine their own action programs with respect to designated nitrate vulnerable zones.

Overall, the degree of restrictiveness relative to environmental regulation varies substantially among OECD countries and regions. It is difficult to quantify whether differences in compliance costs have had a significant impact on farm competitiveness and the pattern of trade and location of agricultural production. Nevertheless, a recent OECD study into linkages between environment and trade in the pig sector concluded that differences in compliance costs arising from the regulation of manure use tends to have much less of an effect on the international competitiveness of pig farms than other factors, including producer support, wage levels, land rents and capital costs. Moreover, while most new regulatory requirements are perceived to increase costs, this is not always the case. In particular, there is evidence that the introduction of tougher environmental standards can sometimes improve on-farm efficiency; for example, through better use of nutrients on the farm, which can cut costs and increase gross margins.

Cross-compliance

In the past two decades, many OECD countries have made general support programs, which provide payments to agricultural producers, conditional upon the respect of certain environmental constraints or the achievement of a particular environmental outcome. Such conditions are a significant part of agri-environmental policy in the U.S., where an estimated 44 million hectares of highly erodible cropland and 31 million hectares of wetlands are subject to cross-compliance provisions, reflecting the high participation rate in general farmer support programs.

Since the late 1990s, most general direct payments offered to farmers in Switzerland, including area and headage payments, and payments based on historical entitlements, have also been made conditional on farmer compliance with environmental standards and farm-management practice requirements. Norway offers various forms of area-based payments and headage support for livestock on the condition that farmers meet environmental requirements. Environmental cross-compliance conditions have also become important in some European Union Member States, following the inclusion of such conditions as an option in the implementation of direct payments, as part of the Agenda 2000 CAP reform package. Cross-compliance conditions, including for the environment, have been extended to most payments received by farmers following the 2003 CAP reform.

While cross-compliance measures are seen in some countries as an important means to integrate environmental objectives into general support measures, a note of caution is warranted. In particular, the effectiveness of such measures may be limited where they are tied to production-linked forms of support that continue to provide farmers with incentives to engage in environmentally damaging activities. Moreover, farmers will only participate where the benefits are sufficiently large that they still have a financial incentive to comply with the restrictions; this can make the attainment of environmental objectives, effectively, a hostage to ongoing support. Cross-compliance may not be best-suited to addressing environmental issues that are of a more local nature.

Information and advisory measures

Research

Many OECD countries have directed greater attention towards improving the knowledge-base relating to environmental issues in agriculture in the past two decades through increased spending on agri-environmental research, often undertaken in cooperation with private sector interests. One notable trend in the past decade has been the development of agri-environmental indicators to improve the monitoring of the environmental performance of agriculture in countries such as Australia, Canada, Denmark, Finland, France, New Zealand, the Netherlands, Switzerland, the U.K. and the U.S., as well as regional initiatives carried out by EU institutions and under the North American Free Trade Agreement (NAFTA).

Enhanced agri-environmental monitoring is now beginning to be utilized in the development and evaluation of policy. For example, in the U.S., agri-environmental indicators have been used in the design of the Environmental Benefits Index (EBI) for targeting payments under the CRP, while agri-environmental indicators are also to be used to evaluate the implementation of environmental policies under Canada's Agriculture Policy Framework, implemented in 2003.

Technical assistance/extension

Increased agri-environmental research has often been complemented by greater emphasis on communicating advice directly to farmers on environmental issues, in order to induce voluntary changes in farming practices to improve environmental outcomes. Most governments have general advisory services and employ extension agents to work with farmers on technology development and transfer. Advice is commonly in the form of codes of good agricultural practice, such as recommended maximum rates for the application of pesticides and fertilizers.

In the past decade new communication tools have been introduced, including the Internet and the use of demonstration or "model" farms. Over time, the provision of information has also tended to encompass an increasingly comprehensive range of information. For example, Environmental Farm Plans in Canada focus on developing risk-management strategies for farmers. Australia's Environmental Management Systems integrate individual environmental farm objectives with regional targets.

In some countries—Australia, Canada and New Zealand—government-led information policies are supplemented by the growing use of community-based approaches promoting the exchange and transfer of information, variously known as landcare groups or conservation clubs. These approaches make use of local expertise in solving environmental problems that thereby enhance environmental conservation, and rely upon the self interest of farmers. Such groups seem especially well-suited to address issues that are local in nature, but which extend beyond the borders of a single farm. Some of these groups receive administrative or financial support from central or regional authorities, while others are entirely self-financed and independent.

Product information

In the past decade, greater attention has also been directed at providing information on the environmental attributes of commodity outputs in order to meet the demands of an increasingly well-informed and discriminating public. In particular, standards for "eco-labels" have been established in many OECD countries, backed-up by certification processes to verify their authenticity, in order to assist customers in distinguishing commodities grown without chemical fertilizers or pesticides from conventionally-produced agricultural commodities. Products from such commodities tend to command discernible price premiums in many markets.

Some of these eco-labelling schemes are entirely market-based, often introduced by producer groups at the behest of supermarkets or other retailers. Others are government-backed. For example, a large number of OECD countries—including Australia, the European Union, Canada, Norway, the U.S. and Switzerland—have introduced government-enforced national organic labelling standards.

It is not an easy task to determine the level of agri-environmental payments in OECD countries. There are payments directly attributable to environmental protection or the enhancement or conservation of natural resources, while other agricultural policies are related directly or indirectly to the environment (for example, natural disaster, general services and regional assistance). Cross-compliance plays an important role in Europe and the U.S. Moreover, environmental regulations affecting agriculture are significant in most OECD countries. From the OECD classification of support—based on how policies are implemented, not in terms of declared policy objectives—the data are presented in Table 1.

Expenditures on agri-environmental programs have increased in most OECD countries since the mid-1990s. In 2000, total monetary transfers to the agricultural *sector* as a whole—measured as the total support estimate (TSE) for OECD countries—amounted to US$321 billion and the *producer* support estimate (PSE) amounted to US$243 billion. In 2005, the respective figures were US$385 billion (TSE) and US$280 billion. As measured by the PSE, payments to farmers for addressing environmental issues in agriculture have increased since the mid-1980s from one per cent to around four per cent of OECD support to producers. These percentages are dominated by market price support policies provided through trade measures, but would account for around 20 per cent of support if only government budgetary transfers were considered. Moreover, these figures do not include agri-environmental spending in other areas, such as research, training, advice; costs associated with regulatory measures; or payments to which environmental "cross-compliance" conditions are attached.

There is a great diversity of agri-environmental payments across OECD countries and regions. In practice, agri-environmental payments tend to be linked to on-farm practices associated with certain environmental outcomes. Payments directly based on environmental outputs such as "improved landscape" or "more diversity" are rare. Since the 1990s, many European countries and the U.S. have greatly increased their use of such measures. Some notable trends include the growing use of payments to support the adoption of less-intensive farming practices; land retirement payments to promote environmental objectives; and transitional payments to assist farmers in implementing structural changes intended to benefit the environment. By contrast, in some countries, payments are made through *community-based* schemes involving local governments and other community groups.

Table 1: Agri-environmental payments in the OECD area

	1995		1998		2000	
	Million USD	Share (%)	Million USD	Share (%)	Million USD	Share (%)
Area/headage	363	8	502	7	465	8
Input use	1,172	27	1,743	26	1,755	29
Input constraints	2,707	62	4,314	63	3,665	60
Historical based	41	1	89	1	87	1
General services	74	2	186	3	168	3
Total	4,357	100	6,835	100	6,140	100
Total Support Estimate (TSE)	368,587		334,440		310,820	
Share in TSE (%)	1.2		2.0		2.0	

Notes on Table 1

Total Support Estimate:
The monetary transfers to the sector as a whole arising from agricultural policies. Turkey is excluded from the TSE estimates shown above.

Transfers:
Area/headage: based on current plantings or animal numbers.
Input use: based on use of specific fixed or variable inputs.
Input constraint: based on limiting the use of specific fixed or variable inputs.
Historical: based on historical support, area, animal numbers or production.
General services: transfers to agriculture as a whole, such as research, infrastructure, inspection and marketing and promotion.

Source: Calculations are based on OECD TSE data.

Future development of AEIs

There are a number of issues concerning the future development of OECD AEIs. There is "unfinished business" related to existing indicators, including streamlining, (both through adding and subtracting from the current set of indicators), so that the indicators are better suited to policy needs and analytical efforts; and the need to better integrate and ensure consistency of indicators at different spatial levels, which would be helped by monetizing physical indicator data.

Unfinished business

To what extent is work still needed on the existing indicators? Concerning the *analytical soundness* of the indicators, there is a mixed picture. For nutrient balances and soil erosion indicators, for example, these are based on robust scientific understandings of nitrogen cycles, soil transport and fate models. In a number of other areas there is still incomplete knowledge. For example, the links between farming activities and biodiversity—including soil biodiversity—are not fully understood, while knowledge of the pathways and extent of agricultural pollutants into groundwater is poor. Indicator *measurability* depends on good data coverage and quality, which also varies across countries. While certain data are regularly collected across most countries through agricultural censuses (for example, land area), surveys are also frequently used to collect environmental data, (such as farm management indicators), and country coverage are typically patchy. Countries often differ in the definition of data coverage. For example, in some countries, pesticide and energy data only include agriculture, but for other countries, they also cover other activities, such as forestry. The *interpretation* of results needs to be undertaken with great care. OECD average trends can mask wide differences between countries, while national indicator trends can also hide large regional and local variations, as is especially the case for nutrient surpluses and water pollution. There are also marked disparities in: absolute indicator levels between countries in nutrient surpluses; pesticide, energy and water use; and air emissions.

The following areas are currently poorly tracked in the OECD AEIs:

- farm pesticide and pathogen pollution of water bodies, especially groundwater;
- soil organic carbon changes in agricultural soils;
- agricultural use of water resources, especially groundwater;
- impacts of farming activities on wild species and ecosystems (biodiversity); and the
- extent of the adoption of environmental farm management practices.

In adition to improving the underlying scientific understanding of agri-environmental linkages, there is a need at the international level to improve the definitions and methods by which indicators are derived and applied to ensure cross-country consistency, which is also recognized more broadly for environmental indicators. The OECD nutrient balance indicator methodology is an example of progress in this respect, as are the international efforts related to greenhouse gas and ammonia emissions indicators, and the common acceptance among researchers of using the Universal Soil Loss Equation (USLE) to measure soil erosion. For other indicators, further improvement of the basic rules governing indicator definitions and calculation methodologies would be useful to help policy analysis in the following areas related to primary agriculture:

- pesticide use and environmental-risk indicators;
- water accounts (surface and groundwater agricultural abstractions and returns);
- ecosystem indicators, particularly semi-natural habitats on agricultural land; and,
- farm management, covering management of nutrients, pests, soil, water and biodiversity.

Integration and consistency

While OECD countries are seeking to improve the quality of the spatial and temporal resolution of their datasets used for the calculation of AEIs, not least because these are needed to implement and monitor policy and ensure that national indicators have meaning at the farm level, more needs to be done including:

- *Integration of databases:* By seeking ways to integrate different agricultural and environmental databases that are commonly collected on a regular basis across most OECD countries (i.e., farm structure surveys, farm account surveys and agri-environmental datasets). For example, frequently, farm structure surveys provide data on land cover changes, while farm account surveys may provide information on farm management practices. The integration of databases can provide the opportunity to achieve value added from existing datasets, which is especially important when additional resources for data collection are scarce.
- *Coupling indicators:* By tracing through the cause-and-effect relationships that are explicit in the *Driving Force-State-Response* framework. For example, as an environmental *driving force*, the pesticide-use indicator is linked to pesticide-risk indicators and the *state* or concentration of pesticides in water bodies. *Responses* to these changes in the state of the environment are

revealed through indicators of pest management and environmental farm planning. Coupling indicators can also provide a means to verify the validity of the change in direction of a given indicator. For example, if the nitrogen surplus balance is showing a rising trend, then it would be expected that this would also be reflected in increasing trends for the ammonia and elements (methane, nitrous oxide) of AEIs for greenhouse gases.

- *Modelling*. Governments are increasingly interested in modelling the effects of different policy instruments on environmental (and other) outcomes, in order to establish which policies are most effective at achieving environmental objectives at least cost. The indicators that are needed in this context need to be specified at a much finer resolution than those that track broad trends.
- *Ease of interpretation*. In order to clearly communicate the state and trends of environmental conditions in agriculture to policy-makers and the public with the least amount of ambiguity, there need to be limits on the number and complexity of AEIs. This is because data needs vary considerably among different groups (for example, researchers need more expansive information than policy-makers and the public, both of which require more condensed indicator sets). Efforts to develop "headline" environmental indicators by some countries are a step in this direction. They attempt to provide a set of indicators that can become as familiar as economic and social indicators such as inflation and employment rates; and can reconcile the need for indicators that address specific agri-environmental issues within a country or group of countries, provide comparative information across countries, and are amenable for use in policy-modelling.

A challenge for policy-makers is to determine the highest priority investments in monitoring and reporting capacity given limited resources and the large array of "policy relevant" environmental issues faced by governments. This involves moving from physical measures of agricultural impacts on the environment to a set of economic or monetary measures of impacts.

Developing a system of national accounts to reflect the full economic costs and benefits to society of agricultural activities on the environment would enable the comparison and evaluation of different environmental issues, which is not completely possible with the use of physical measures. Hence, a system of national accounts would make it possible to compare the relative costs of water pollution versus soil erosion, or comparing the benefits of conserving biodiversity versus sequenstering carbon in farmed soils.

There are many difficulties in measuring the economic costs and benefits of agriculture on the environment; especially estimating benefits relating to ecological services where markets frequently do not exist (for example, biodiversity). A number of countries have begun to estimate the environmental costs and benefits of farming activities. The U.K., for example, is developing preliminary monetized environmental accounts for the country's agricultural sector.

In order to better serve the needs of policy-makers and the public, greater efforts are needed to strengthen indicator networks between OECD and: other international organizations (such as FAO, Eurostat, European Environment Agency, Convention on Biological Diversity, UN Commission on Sustainable Development); scientists, developers of indicators, policy analysts, farmers, and the agri-food chain (such as the major multi-national food corporations that have developed sustainable indicators for their own management purposes); and non-OECD countries. Efforts are also needed to strengthen indicator networks between governments and non-governmental organizations (such as BirdLife International, WWF and IUCN).

Strengthening indicator networks would potentially help avoid the duplication of efforts, bring (or link) together the best expertise in developing indicators from scientific, policy and practical perspectives, and possibly lead to some harmonization of indicator definitions, calculations, uses in modelling, and interpretation of results. They could also provide forums for thinking about the future development of indicators—into new or difficult areas, contributing to developing the monetization of physical indicator values so as to allow comparisons of overall environmental trends across time and countries, finding lower-cost proxy indicators (such as farm management practices or land uses), and considering the suitability of transferring OECD-country experiences in developing indicators to non-OECD countries. Another dimension that warrants more attention is the relationship between national, regional and farm-level indicators.

That being said, to date the development of indicators has been very resource intensive, and many rely on existing public sources of information. Many governments are reluctant to devote more of their scarce resources to develop new indicators. Agri-environmental indicators are relatively young in relation to many established economic and social indicators. Not enough is known as to the extent and ways in which agri-environmental indicators are actually used in the design, implementation and assessment of policies. An international conference to bring together all those groups and disciplines involved—as consumers or providers of agri-environmental indicators—might be a fruitful place to start.

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FAO use of Agri-environmental Indicators and Potential Partnerships

Géraud Servin

G. SERVIN – Food and Agriculture Organization of the United Nations (FAO), Liason Office with the European Union and Belgium, Bd Simon Bolivar, 30 1000 Brussels, Belgium

Abstract

The concept of agriculture has expanded significantly—it is now beyond a matter of production and productivity. This is evidenced by the array of ecosystem services articulated in the Millennium Development Goals (MDGs). Likewise, agri-environmental indicators are cross-cutting and have several functions related to application in practice, programming and policy assessment. For agri-environmental indicators to reach their potential, several constraints need to be addressed, as are outlined in this paper. The Food and Agriculture Organization of the United Nations (FAO) is a widely-used data provider for agri-environmental global, regional and national assessments. An important key to increased use of indicators in policy-making is ongoing dialogue between policy-makers and information providers. This paper concludes with the identification of several potential partnerships with key international initiatives.

Keywords: agri-environmental indicators, sustainable agriculture, FAO data, FAO statistics, international partnerships.

Introduction

This paper provides a synthetic overview of the use of agri-environmental indicator by the Food and Agriculture Organization of the United Nations (FAO); raises major issues; and explores possible partnerships between key international initiatives.

1. Sustainable agriculture and rural development

The concept of sustainable development was introduced in the 1987 report of the Brundtland Commission on Environment and Development to shift attention away from narrow sectoral interests and towards an integrated approach comprehensively embracing environmental, social and economic goals. The concept of Sustainable Agricultural and Rural Development (SARD) emerged in the early 1990s as a framework for focusing greater attention on sustainability issues

Table 1: Ecosystem services (Millennium Ecosystem Assessment, 2003).

Provisioning services	Regulating services	Cultural services
Products obtained from the ecosystems	Benefits obtained from regulation of ecosystems' processes	Non-material benefits obtained from ecosystems
Food	Climate regulation	Spiritual and religious
Freshwater	Disease regulation	Recreation and ecotourism
Bioenergy	Water regulation	Aesthetic
Fibre	Water purification	Inspirational
Biochemicals	Pollination	Educational
Genetic resources	Sense of place	Cultural heritage

Supporting services
Services necessary for the production of all other ecosystem services
Soil formation
Nutrient cycling
Primary production

within agricultural and rural development processes in both developed and developing countries. Agriculture and rural development are sustainable when they are ecologically sound, economically viable, socially just, culturally appropriate, humane and based on a holistic scientific approach.

Agriculture is no longer a simple question of production and productivity. The conceptual framework developed for the Millennium Ecosystem Assessment (MEA) goes way beyond these functions when defining ecosystem services. These services include provisioning, regulating, and cultural services that directly affect people, and supporting services needed to maintain the other services (Table 1).

2. Data constraints and solutions

Comprehensive assessment and reporting systems are needed to devise efficient initiatives to improve sustainable agriculture and measure their success. Indicators are essential tools for:

- providing information on the current state and changes in the conditions of the environment in agriculture;
- understanding and monitoring the linkages between agricultural practices and their beneficial and harmful effects on the environment;
- identifying the key agri-environmental issues that are of concern today;
- elaborating agri-environmental measures and policies, with the aim to achieve the most significant progress in reducing agriculture's impact on the environment where environmental pressures are greatest;
- assessing the extent to which agricultural and rural development policies respond to the need to promote environmentally-friendly farming activities and sustainable agriculture;
- communicating to policy-makers and the wider public; and
- tracking progress of targets (e.g., Kyoto Protocol and the Millennium Development Goals (MDG)).

Although progress has been made during the past decade in using indicators to inform policy-makers and support sustainable agriculture, a number of technical and institutional problems (Table 2) constrain further improvement. Among these include: low investment in baseline

Table 2: Technical and institutional constraints and solutions for indicators (LADA, 2006).

Technical	
Constraint	**Solution**
Baseline information for most indicators does not exist or is outdated (80s). Therefore, projects often have to start from scratch. Most analyses use data from the same limited pool.	Obtain **relevant, up-to-date and reliable** baseline information on the state of ecosystems supported by hard data not only obtained by remote sensing, but also by ground surveys.
Interpretation of cause-and-effect is often anecdotal and not mathematically correlated. Even if correlations are high, interpretations may differ. Excessive error in some key global data sets (e.g., land use).	Use **simple methods** and the least possible number of indicators to set-up cost-effective systems. Enhance networking and **develop partnerships** across organizations, such as governmental bodies, national statistical offices and research communities. Increase the participation of NGOs and civil society in a more coherent manner to allow more reliable assessments.
Geo-referencing of statistical data is limited and **discrepancies** occur between databases (e.g., 70 per cent difference between World Bank and FAO for annual industrial water withdrawals for Australia in 2000).	Promote **geo-spatial data, standardization and harmonization** to ensure consistency, coherence and inter-operability of data.

Institutional	
Constraint	**Solution**
Sub-national data are not available for socio-economic indicators, consequently up-and-down scaling becomes difficult, if not impossible.	All levels of assessment investigation are important, but the national level is the **core level** at which decisions can most influence impacts and initiate remedial action at the institutional level. That is the level at which scientific results should be collated first.
Ownership and access to the monitored information. Often copyright, sensitive and privacy issues arise and governments and private land owners are not at all eager to share and interpret the information collected.	Local levels are important to providing valuable information, which leads to taking appropriate concrete actions with visible results and involves land users as well as direct decision-makers. Therefore **local actors** have to be involved in a participatory approach because follow-up and sustainable management cannot take place without them.
Costs ranging from between 5,000 and 25,000€ per site per timed observation (e.g., forest soils monitoring in Europe). Declining or low national investment in agri-environmental data collection.	Greater reliance on **remote sensing** to reduce costs to US$10 to 100 per site complemented with ground validation and field sampling analysis. Build on existing assessment systems and networks.

data collection; and limited geo-referencing of statistical data. Such constraints result in most studies using largely the same data, reaching largely the same conclusions and therefore producing a slow rate of policy adjustment and implementation.

Confusion also exists between various set of indicators (Table 3). Obviously some indicators are common in order to create synergies and avoid the duplication of efforts. Therefore a judicious selection is required. Indicators should be SMART: Specific, Measurable (preferably cheaply), Achievable, Relevant, Time-bound, available or at least observable/obtainable, socially and politically acceptable.

Table 3: Major list of indicators related to sustainable agriculture and development.

Major list of indicators related to sustainable agriculture and development	Total number of indicators
Agriculture and the Environment in the EU-15 – the IRENA Indicator Report (2005)	35
European Environmental Indicators (EU) – core set of indicators (2005)	37
Organisation for Economic Co-operation and Development (OECD) – agri-environmental indicators (2001)	39
UN Indicators of Sustainable Development – additional indicators (2005)	45
UN Millennium Indicators Database (2005)	48
UN Indicators of Sustainable Development – core indicators (2005)	54
UN Water Corporate Database of key indicators (2006)	64
Land Degradation Assessment in Drylands (LADA) – indicators toolbox (2005)	84
World Bank Development Indicators on agriculture and development (2006)	98
Terrestrial Ecosystem Monitoring Sites (TEMS) – environmental indicators (2006)	120
European Environmental Indicators (EU) – other published indicators (2001 to 2004)	196

An alternative is to adopt criteria guiding the selection of indicators. For example, for measuring, assessing and reporting on progress towards sustainable forest management, the following criteria have been globally accepted by countries:

- extent of forest resources;
- biological diversity;
- forest health and vitality;
- productive functions of forest resources;
- protective functions of forest resources;
- socio-economic functions; and
- legal, policy and institutional framework.

Indicators are developed and implemented according to countries' environmental, socio-economic, political and even overall cultural conditions.

FAO is working with a number of partners to improve the data available for analyzing and understanding large-scale agri-environmental change, including multi-lateral environmental agreements on biological diversity, climate change and combating desertification. Among the solutions are: increased use of field sampling; greater reliance on remote sensing; assimilation and integration of multiple data sources; and adoption of standards.

3. FAO data in assessments

As a major user and provider of statistics related to agriculture, nutrition, fisheries, forestry, food aid, land use and population, FAO data are widely used (Table 4) in global, regional and national assessments.

Table 4: Flagship publications and databases using FAO data.

Flagship publications and databases using FAO data	Publisher
Atlas of Population and Environment (2000)	American Association for the Advancement of Science (AAAS)
Agriculture and environment in EU-15 – the IRENA Indicator Report (2005)	European Environment Agency (EEA)
Global Forest Resources Assessment (2005)	FAO

Flagship publications and databases using FAO data	Publisher
State of Agricultural Commodity Markets (2004)	FAO
State of Food and Agriculture (2005)	FAO
State of Food Insecurity in the World (2005)	FAO
State of the World's Forest (2005)	FAO
State of World Fisheries and Aquaculture (2004)	FAO
Wellbeing of Nations (2001)	International Development Research Centre (IDRC)
OECD Environmental Data Compendium (2004)	Organisation for Economic Co-operation and Development (OECD)
OECD Factbook (2005)	Organisation for Economic Co-operation and Development (OECD)
ComTrade database	UN Statistics Division (UNSD)
Global Environment Yearbook (GEO) (2006)	United Nations Environment Programme (UNEP)
Global Resources Information database (GRID)	United Nations Environment Programme (UNEP)
Where is the Wealth of Nations? (2005)	World Bank
World Development Indicators database	World Bank
Earth Trends online reporting database	World Resources Institute (WRI)
World Resources (2005)	World Resources Institute (WRI)
Living Planet Report (2004)	WWF

4. Link to policy

The evolution of political processes and knowledge systems is highly related and interdependent. In order to work towards knowledge-based policies and to develop a functional information system for the achievement of sustainability objectives, it is extremely important to enhance the dialogue between policy-makers and information providers. This will lead to a greater understanding of the issues and responsibilities by both politicians and technicians to attain sustainable agriculture.

For example, during the 11th session of the UNFCCC Conference of the Parties, the Subsidiary Body for Scientific and Technological Advice (SBSTA) "welcomed the efforts by the Global Terrestrial Observing System (GTOS) secretariat to develop a framework for the preparation of guidance materials, standards and reporting guidelines for terrestrial observing systems for climate. It also called on the GTOS secretariat to assess the status of the development of standards for each of the essential climate variables in the terrestrial domain and to report on its progress by SBSTA 26 (May 2007)." (UNFCCC, 2005). Thus thirteen variables found their way into a highly influential arena:

- albedo;
- biomass;
- fire disturbance;
- fraction of absorbed photosynthetically active radiation (fAPAR);
- glaciers and ice caps;
- ground water;
- lake levels;
- land cover (including vegetation type);
- leaf area index;
- permafrost and seasonally-frozen ground;
- river discharge;
- snow cover; and
- water use.

5. Potential partnerships

The following international initiatives listed in this section could provide some guidance toward the establishment of long-term partnerships for the collection, analysis and impact of agri-environmental indicators on sustainable development; the ultimate objective being to build capacity in countries and add value to the agricultural and environmental sectors.

5.1. Assessment and projects

Millennium Development Goals (MDG)

While the agricultural sector provides critical inputs to attaining the MDG targets, broad improvements in human capital needed to reach those targets might also provide an important foundation from which a considerably more productive and resilient agricultural sector can be developed. While most MDG targets are complementary, some might actually involve tradeoffs. For example, enhanced access to improved drinking water sources might collide, in some regions, with the goal of reduced hunger through increased irrigated agriculture. Similarly, several indicators of MDG 7, ensuring environmental sustainability, might well be adversely affected by efforts aimed at increasing agricultural and economic development that are important for the achievement of MDG 1.

MDG 7 covers a broad sweep, including biodiversity, critical natural habitats, energy use and global climate change, unsafe water and poor sanitation, and urban slums. Agriculture is implicated both as a means to effectively address many of these problems, and as a source of and a contributory factor to the problems that MDG 7 was formulated to address. In this light, a judicious, comprehensive and participatory assessment of the environmental costs and benefits must be undertaken in the planning process for any agricultural development efforts.

The underlying driving force for environmental degradation through agricultural expansion and the harmful use of farming technologies is frequently poverty, rather than factors inherent to agriculture itself. If farmers realize personal economic benefits and also recognize the social benefits from environmental protection, they will respond to these incentives and employ environmentally-sustainable production techniques. However, sustainable agricultural practices must be profitable for this to happen.

International Assessment of Agricultural Science and Technology for Development (IAASTD)

The IAASTD is a unique international effort that will evaluate the relevance, quality and effectiveness of agricultural knowledge, science and technology (AKST); and the effectiveness of public and private sector policies, as well as institutional arrangements in relation to AKST. It is a three-year collaborative effort (2005–2007) involving 110 countries that will assess, at the global and regional levels, AKST in relation to meeting development and sustainability goals of: i) reducing hunger and poverty; ii) improving nutrition, health and rural livelihoods; and iii) facilitating social and environmental sustainability.

Land Degradation Assessment in Drylands (LADA)

The Land Degradation Assessment in Drylands (LADA) project aims to develop assessment tools to collect up-to-date information on the status of land at local, national and global levels. To achieve this aim, LADA uses a flexible methodological framework that relies on traditional and digitally-assisted methods of data collection. The LADA project will produce an overview of the global status, pressures and causes of land degradation, indicating hot spots and bright spots. Six pilot countries will produce higher resolution assessments which will allow the further refinement of the methodological framework.

LADA responds to the needs of all stakeholders concerned about land degradation, and, in particular, the ones involved in the implementation of the action programs of the Convention to Combat Desertification (UNCCD). Both the global assessment and country assessments will serve as a baseline to design policies for combating land degradation and rehabilitate degraded land. This baseline will also allow countries to monitor the success of these policies.

International Bioenergy Platform

This century could see a significant switch from fossil fuel to bioenergy-based economies, with agriculture and forestry as the leading suppliers of biomass for energy carriers such as wood, charcoal, pellets, bioethanol, biodiesel, synthetic gasoline and bioelectricity. Because of the potential implications for food security, commodity trading and overall rural development of this massive move towards bioenergy, FAO has prepared an International Bioenergy Platform (IBEP), which should assist in facilitating the required international cooperation in this field.

The overall objective of IBEP is to ensure the delivery of sustainable, equitable and accessible bioenergy sources and services in support of sustainable development, energy security, poverty reduction and climate change mitigation. Its immediate objectives include: providing the best-available information and analysis for decision-making and policy support; and helping to define and design bioenergy production and utilization systems that promote sustainable development and the MDGs. Among the main outputs of IBEP are information delivered to decision-makers through the diffusion of practical bioenergy assessment, planning and development tools and guidelines.

Another major output expected from IBEP is to provide guidance on the food security and bioenergy nexus, highlighting both opportunities for synergies and also areas of potential conflict between different land uses in provision of food, feed, fibre, paper, timber and energy, under different local, regional and global bioenergy scenarios. Better data, information and indicators are required in order to fulfil these objectives and outputs. IBEP, with FAO in partnership with the United Nations Environment Programme (UNEP), the Global Environment Facility (GEF), the International Atomic Energy Agency (IAEA), the United Nations Development Programme (UNDP) and others, considers this an area of highest priority.

TerrAfrica

TerrAfrica's mission is to work towards unlocking critical bottlenecks to achieve a significant scale up in the financing and mainstreaming of effective and efficient country-driven sustainable land management (SLM) practices. Its objective is to build capacity and strengthen the enabling environment around SLM, and thus, remove the barriers to scaling up the mainstreaming and financing of country-driven SLM. TerrAfrica will aim to help partners:

- harmonize and coordinate their efforts at the policy, strategy, technical and program levels;
- expand and consolidate actions that support SLM;
- benefit from qualitatively and quantitatively increased flows of knowledge, information and expertise to and from members;
- better mobilize and channel financial resources; and
- provide and obtain mutual encouragement for and support of their commitment to SLM.

5.2. Observing community

Group on Earth Observations (GEO)

GEO is an international partnership leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS) over the next 10 years. GEOSS will work with and build upon existing national, regional, and international systems to provide comprehensive, coordinated Earth observations from thousands of instruments worldwide; transforming the data they collect into vital information for society.

Global Monitoring for Environment and Security (GMES) and for Food Security (GMFS)

GEMS represents in simple terms a concerted effort to bring data and information providers together with users, so they can better understand each other and agree on how to make environmental and security-related information available to the people who need it. A challenge for GMES is to gather relevant data and provide innovative, cost-effective, sustainable and user-friendly services, which will enable decision-makers to better anticipate and integrate crisis situations into the management of environment and security.

GMFS aims to: provide earth observation-based services; and encourage partnerships in monitoring Global Food Security and related environmental processes. The latter is completed by bringing data and information providers together, in order to assist stakeholders, nations and international organizations in improving their implementation of sustainable development policies.

Terrestrial Ecosystem Monitoring Sites (TEMS)

TEMS is an international directory of sites (ca. 2050) and networks (40) that carry out long-term terrestrial monitoring (ca. 120 standardized variables) and research activities. The database provides information on the "who, what and where" that can be useful to both the scientific community and policy-makers. TEMS also provides a mature framework for qualitative change assessment, scientific datasets registration and sharing as well as satellite sensors ground validation.

5.3. Statistics

2010 World Census of Agriculture

As in previous rounds, the 2010 round of agricultural censuses will mainly focus on measuring structural aspects of crop and livestock production at the agricultural holding level. A new element will be the collection of data at the community level, such as the village. This will include data on infrastructure and other community-level services.

FAOSTAT2 and CountrySTAT

FAOSTAT, the FAO statistical database, is an online multi-lingual database currently containing over three million time-series records from over 210 countries and territories covering agriculture, nutrition, fisheries, forestry, food aid, land use and population. Data collection relies on questionnaires submitted by member countries. The new system (FAOSTAT2) seeks to provide better access to data, ensure that data is of consistently high quality and enhance data dissemination mechanisms. It also includes CountrySTAT, a country-appropriate version of FAOSTAT2 that allows countries to develop and implement a statistical information system relevant to their specific agricultural situations.

CountrySTAT seeks to strengthen capacity of member nations to coordinate, harmonize and enhance the value of their data collections. It provides countries with basic tools for verifying, validating and deriving analytical indicators for uses such as food balance sheets or supply/utilization accounts. It encourages coordination and consolidation among various data collections at national and sub-national levels. In 2005, national projects started in three pilot countries and will be further implemented in 20 additional countries.

The data stored in CountrySTAT databases are organized in two major groups: CountrySTAT Core, which contains national data shared with FAOSTAT database; and the CountrySTAT Sub-national, composed of data owned by various national authorities. This arrangement of CountrySTAT Core and Sub-national provide end-users with the possibility of "navigating" throughout data starting from either geographic or thematic paths. CountrySTAT is also committed to creating protocol and procedures for exchanging data via human-readable and platform-independent documents written in languages such as XML, which allow direct and open data harvesting from national web servers.

WOCAT and AQUASTAT

The World Overview of Conservation Approaches and Technology's (WOCAT) mission is to provide tools that allow Soil and Water Conservation (SWC) specialists to share valuable knowledge in soil and water management. This assists specialists in their search for appropriate SWC technologies and approaches, and supports them in making decisions in the field and at the planning level.

AQUASTAT is FAO's global information system of water and agriculture developed by the Land and Water Development Division of FAO. The objective of AQUASTAT is to provide users with comprehensive information on the state of agricultural water management across the world, with emphasis on developing countries and countries in transition.

5.4. FAO and the private sector

The FAO Director-General has stated that: "the challenge of food security can only be resolved through a global partnership involving national, international, public, private and voluntary sectors" (FAO and the Private Sector, 2007). A healthy private sector and well-functioning markets are key factors for economic growth and the sustainable development of the agriculture, food, fisheries and forestry sectors.

Currently, FAO works with a range of international and national private sector partners of the agriculture and food chain. It also actively promotes policies in member countries that foster private investment and private sector growth. The private sector is an important ally in our fight against hunger. The much needed financing and investment to attain the MDGs will have to come, for the most part, from private resources and investment.

FAO seeks to increase private sector participation in food security and other agricultural development programs through partnership activities that can help achieve:

- policies that facilitate private sector development and investment. Economic, regulatory and administrative policies need to address the concerns of the private sector, creating an environment for healthy business activity;
- improved capacity for entrepreneurship in developing countries. Most of the new investment needed to achieve the MDG of reducing hunger will be at the farm level. Farmers often lack human and capital resources to start or expand their business-

es. Local private sector capacity can be enhanced by assisting farmers and other small businesses in improving their business knowledge and providing them with tools for better management;

- improved and sustainable agricultural production. Investment in primary agriculture is one way to increase incomes and reduce hunger. Over 70 per cent of the poor live in rural areas and depend on agriculture for their survival. Better technology and improved practices can help increase production and make it more sustainable; and
- more effective information systems. In today's globalized world, people rely on various information systems to be able to compete in world markets and expand their reach. Market information systems for example, are essential to develop and expand trade in commodities.

Conclusion

Global initiatives like the MEA and MDGs brought the importance of agri-environmental indicators back on international fora. Therefore, in the past decade, good progress has been made in producing and using such indicators to inform policy-makers about sustainable development issues.

However a number of technical and institutional barriers are still limiting further improvement. First among these is low investment in baseline geo-referenced data collection, especially at the sub-national level. Establishing networks of experts, operating and connected at different scales, and strengthening existing institutional partnerships, could be a solution to improve the production, analysis, sharing and utilization of agri-environmental indicators.

The work on agri-environmental indicators has now penetrated both the private and public sectors and collaboration across these two entities and scales will be essential. Ultimately, these collaborative activities will strengthen our collective ability to communicate sustainability trends to the public and policy-makers. The impact of indicators will be determined by the ability of these audiences to make use of them.

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Section 4

Synthesis of the Symposium in Bern and Future Horizons for INFASA

László Pintér, Fritz J. Häni and Hans R. Herren

L. PINTÉR – International Institute for Sustainable Development (IISD), Winnipeg.

F. HÄNI – Swiss College of Agriculture (SHL), Bern University of Applied Sciences.

H. R. HERREN – Millennium Institute, Arlington, Virginia.

The underlying premise of the International Forum on Assessing Sustainability in Agriculture (INFASA) is that the assessment of the sustainability of agricultural production is of growing interest to producers, policy-makers, the agri-food industry, and not least of all the general public. This can be demonstrated by the sheer number and diversity of initiatives that aim to provide information about the economic, social and ecological aspects of agricultural production and the more encompassing food, feed and fiber systems.

There are many reasons for the increasing demand for better information and evidence to support the design of sustainable production policies. At the heart of it is a profound public interest in ensuring a secure and resilient future for the world's supply of agricultural goods while maintaining healthy agro-ecosystems and their services. However, it is also a result of the agricultural sector's self-interest, which is recognizing that both regulators and market conditions are increasing their expectations with regard to sustainability.

Capitalizing on the synergies among the multitude of diverse agricultural assessment methods and initiatives can lead to increased potential for positive change. This potential is not unique to agriculture, as demonstrated by the already large and continuously growing number (and growing diversity) of measurement efforts worldwide from the individual enterprise to the whole sector or from the community to regional, national or international scale.[1] The need to strengthen statistical systems and indicators in measuring the progress of societies and evidence based decision-making was generally emphasized in the Istanbul Declaration adopted by the Organisation for Economic Co-operation and Development (OECD), the Organization of the Islamic Conference, the United Nations, the United Nations Development Programme and the World Bank.[2]

The INFASA Symposium in Bern, Switzerland, provided an opportunity to review good practices in sustainability evaluation at the farm and higher organizational level (be it regional, national or international) and explore connections between the two, even if those connections are often not strong or explicit. From a conceptual point of view the challenges faced at the farm or higher organizational levels are partly the same. In a globalized agriculture it is important to standardize measurement tools and methods in order to compare different countries and find

1 IISD, 2006, Compendium of Sustainable Development Indicator Initiatives, http://www.iisd.org/measure/compendium.asp.

2 OECD, 2007, Istanbul Declaration, http://www.oecd.org/dataoecd/14/46/38883774.pdf.

deficiencies and potentials in specific places and farm types. Because sustainability is highly contextual, the interpretation of results received through standardized methodology requires the consideration of the existing framework conditions. Target setting, selection of indicators, and appropriate aggregation algorithms are some of the key methodological issues that surface at all levels. A holistic, systems-based yet practical approach to assessment is key, as sustainability decisions often involve tradeoffs. The need to understand such tradeoffs and to capitalize on win-win situations necessitates a broad-based view of socio-economic and ecological parameters and linkages.

As some of the examples presented at the Symposium have illustrated, motivations for developing and using assessment tools may vary. At the farm level, indicator systems can detect deficiencies as well as strengths and thus support management decisions. This can lead to improved specific practices whether related to cropping systems, farm economics or social conditions. However, producers are also increasingly drawn into adopting measurement tools associated with farm environment plans and certification systems. In the case of farms having long-term industry contracts, monitoring key indicators is necessary to meet corporate management standard and quality requirements. Here, market expectation is important, as both regulators and ultimately consumers are increasingly interested in food meeting social and environmental criteria. Furthermore, the public today expects stronger evidence to demonstrate positive impact, rather than be content with a green or socially responsible image. Weak evidence may even undermine claims to the positive effects of socially and ecologically beneficial farming practices. Standards, certification and payments for agro-ecosystem goods and services are prominent policy areas that require a strong evidence base.

From a policy point of view, the viability and impact of the agricultural sector as a whole is of interest. Therefore some assessments address higher organizational levels. Such assessments should build on information that is relevant to the farm level, but also include measures that are of primary interest to decision-makers involved in higher level policy making.

The policy demand for better information on agricultural sustainability is diverse. Sustainability evaluation can support premium schemes, paid for by willing consumers expecting agricultural products to meet higher sustainability standards. There is also growing interest in payments for services arising from the multi-functionality of agriculture, which need to meet tough criteria to ensure green box compliance related to trade agreements. An excellent example of a well-administered policy includes direct payments since 1990 by the Swiss government, to specific achievements related especially to evaluated ecological performance and animal well-being.[3]

The food industry, which was represented at the Symposium by corporations such as Nestlé and Unilever, is interested in maintaining competitiveness and a high quality in products, which requires *demonstrably* meeting minimum standards of sustainable production and often connected food safety issues. Besides responding to consumer preferences and regulatory expectations, the food industry is interested in assessment and a stronger evidence base also because it helps clarify and mitigate the risks arising along increasingly long and complex supply chains.

As presentations at the Symposium demonstrated, there is a large and growing diversity of government, corporate and farm-level measurement initiatives. Innovation and experimentation is happening at different organizational levels and on multiple scales. However, despite some shared goals and objectives, coordination is limited. It is not difficult to see how the multiplicity of measurement and assessment approaches can lead to regulatory conflicts and confusion on the part of consumers, let alone the burden it puts on farmers as ultimate providers and users of information.

The need for the coordination of measurement efforts related to sustainable agriculture has been recognized, at least at higher organizational levels, and has lead to early initiatives such as work under the umbrella of Sustainable Agriculture and Rural Development (SARD), tabled in the early 1990s. On the international scene, organizations such as OECD and FAO play a key role. The OECD's agri-environmental indicator program has over the years helped advance the work of several member states in this area, while FAO-coordinated efforts have focused more on the global level, including developing countries. Agriculture-related indicators are also included in the generic sustainable development indicator menu prepared by the UN Division for Sustainable Development (UN–DSD). While these coordination efforts helped advance the agricultural sustainability measurement agenda, they have not yet resulted in common tools, methods and strategies to best use them in a wider variety of settings, certainly not at the farm level and only to a limited extent at higher organizational levels.

3 Cf., contribution in this book by Bötsch, M. and Jung, V.

Here, INFASA is indeed filling a gap by initiating a dialogue between all involved stakeholders and across diverse policy and application contexts. This dialogue should result in more focused coordination and harmonization efforts. It should also lead to improved sustainability assessment tools and their broad application from farm to higher organizational levels. Options for INFASA's organization and strategy were discussed at the Symposium, and they were further explored in a discussion paper commissioned by IISD that looked at experience with major criteria and indicator (C&I) initiatives at the strategic level around the world and the potential lessons from these for INFASA.[4]

In the short to medium term, INFASA will continue to serve as a forum for sharing experience with measurement tools in different contexts, ranging from farm to higher organizational levels. Besides providing a forum for dialogue on applied research, INFASA can help identify and articulate problems such as those related to data availability, and communicate these to key players and initiatives dealing with such issues in a broader context. The demand for a strengthened evidence base highlighting results from implemented measures can be expected to grow for reasons outlined earlier. Therefore it is crucial to anticipate these policy needs in advance and actively address them.

It is equally important to understand both the needs and capacity constraints of producers, and ensure that assessment tools required at the farm level are harmonized with the needs at higher levels and vice versa. Given producers' limited capacity and time, the use of assessment tools should provide an added value for the farmer by supporting his or her management decisions. Engaging the corporate sector is especially important given its increasing weight and interest in demonstrating real social and environmental responsibility to consumers, regulators and shareholders. Considerable efforts have already been made in niche markets, and the demand for mainstream initiatives like the SAI Platform, the Common Code for the Coffee Community (4C Association) or the Round Table on Responsible Soy (RTRS) is increasing.

The INFASA Symposium helped showcase many of the most innovative tools and methods, but effective learning requires interactions between research teams over more extended periods of time, as it was already shown by C&I initiatives at the strategic level. However, because INFASA

4 Wunderlich, C. and A. Russillo, 2006, "Survey of Prominent Criteria and Indicator Initiatives at Strategic Level: Lessons Learned and Needs Assessment," Working paper for the International Forum on Assessing Sustainability in Agriculture (INFASA). Winnipeg, MB: International Institute for Sustainable Development (IISD).

strives to integrate all levels, the task will be even more of a challenge. But relevant indicators and appropriate assessment tools are such critical leverage points in realizing sustainable agriculture, and agriculture itself is of such importance to the future of human well-being that we can hardly afford *not* to try to respond to this challenge. Our vision is that INFASA may play an important role as an open platform for those who want to contribute to this mission.

About the editors

Fritz J. Häni (PhD)
Co-chair INFASA
Swiss College of Agriculture (SHL), Bern University of Applied Sciences, Zollikofen, Switzerland

Dr. Häni is a Professor of Plant Pathology, and Head of the Agroecology Program at the Swiss College of Agriculture. He has been working for many years on national and international projects, in particular dealing with agro-ecosystems; natural regulation; functional biodiversity; and ecologically-oriented and integrated farming systems. Prof. Häni is an editor and author of a number of books on these subjects that have been translated in many languages. In recent years his work has been focused on sustainability indicators and assessment (model RISE: Response-Inducing Sustainability Evaluation). He is a Co-founder of the Swiss Society of Phytiatry (Plant Protection), a society of the Swiss Academy of Sciences.

László Pintér (PhD)
Co-chair INFASA
International Institute for Sustainable Development (IISD), Winnipeg, Manitoba, Canada

Dr. László Pintér has worked with IISD since 1994 and is currently the Director of Measurement and Assessment. His areas of expertise include the conceptualization, establishment and use of integrated indicator, assessment and reporting systems in the context of sustainable development strategies. He leads IISD's collaboration with the United Nations Environment Programme (UNEP) on capacity building for integrated environmental assessment and IISD's five-year collaborative project with Agriculture and Agri-Food Canada (AAFC) in the areas of social indicators, full-cost accounting and international cooperation. Dr. Pintér is also Co-founder of the Canadian Sustainability Indicators Network (CSIN).

Hans R. Herren (PhD)
President Millennium Institute,
Arlington, Virginia, USA

Dr. Herren is well known for launching the very successful Africa-wide Cassava Mealybug Biological Control Program. In recognition of his distinguished achievements in research in insect science, modelling and sustainable development, he has been elected to the U.S. National

Academy of Sciences. In 1995, he received the World Food Prize and in 2003 the Tyler Environmental Prize. Dr. Herren is Co-chair of the International Assessment of Agricultural Knowledge, Science and Technology, (IAASTD); President of BioVision, a Swiss foundation with a global mandate to alleviate poverty while maintaining the precious natural resource base that sustains life; and President of the International Association of Plant Protection Sciences (IAPPS).

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Sustainable Agriculture: From Common Principles to Common Practice

Agriculture is changing rapidly with advancements in science, shifting consumer preferences and environmental impacts. It has long been maintained that the use of assessment and indicator tools is central to achieving secure and resilient supplies of agricultural commodities while supporting healthy agro-ecosystems. As the number and complexity of measurement initiatives increases, there is growing potential for duplication of effort and contradictory messages to regulators, producers and consumers. To respond to what has been noted by government and industry alike as a significant gap in dialogue and collaboration, the International Forum on Assessing Sustainability in Agriculture (INFASA) was initiated as a platform for dialogue in March 2006. *Sustainable Agriculture: From Common Principles to Common Practice* explores the nexus of agricultural assessment in policy and application in this collection of papers from international agencies, governments, researchers and agricultural specialists. This landmark publication stems from the First Symposium of INFASA, held in Bern, Switzerland, March 2006. Full proceedings are available on an accompanying CD.

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