Sustainability Indicators for Natural Resource Management & Policy

Working Paper 1

A Review of Indicators of Agricultural and Rural Livelihood Sustainability

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February 2000

ISBN: 1 902518616

The effects of policy and institutional environment on natural resource management and investment by farmers and rural households in east and southern Africa

(Department for International Development Research Project No. R7076CA)

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Background to Project and Working Paper Series

This paper is one in a series of working papers prepared under a research project on '*The Effects of Policy on Natural Resource Management and Investment by Farmers and Rural Households in East and Southern Africa'*.

This is a collaborative research project implemented by Agricultural and Rural Development Research Institute[1], the Development and Project Planning Centre[2], the Economic Policy Research Centre[3], the Institute for Development Policy and Management[4] and the Centre for Agricultural, Food and Resource Economics[4]. The project is supported by the UK Department for International Development (DFID) under their Natural Resources Policy Advisory Department (NRPAD) research programme. The project commenced on 1 July 1998 and is to run for a three year period.

The overall goal of the project is for it to assist in the development of more effective, equitable and sustainable participatory management of renewable natural resources in sub-Saharan Africa. The purpose of the research is to identify the links between the sustainability of different farming systems and agricultural policy in South Africa and Uganda.

This is to be achieved through a series of case studies in Uganda and South Africa which will examine "the success or sustainability" of small and large scale systems from a range of perspectives including: farmers, communities, scientists, planners and policy makers. This will include the identification of criteria used to assess the "success" of these systems, and the adoption or development of verifiable and measurable indicators of this "success". The impacts of different polices on the degree of success of these systems will be assessed in terms of their effect on farmers' management of, and investments in, their natural resources, and in the development of sustainable rural livelihoods.

This paper *'A Review of Indicators of Agricultural and Rural Livelihood Sustainability'* is the first in the series of the project working papers. The paper summarises a global literature review on the development and use of sustainability indicators for the assessment of the sustainability of natural resource systems.

This research was funded by the Department for International Development of the United Kingdom. However, the findings, interpretations and conclusions expressed in this paper are entirely those of the author(s) and should not be attributed to the Department for International Development, which does not guarantee their accuracy and can accept no responsibility for any consequences of their use.

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Project Working Papers to date

1. A Review of Indicators of Agricultural and Rural Livelihood Sustainability

2. A Framework for Research on Sustainability Indicators for Agriculture and Rural Livelihoods

3. Natural Resource Management and Policy in Uganda: Overview Paper

4. Natural Resource Management and Policy in Eastern Cape Province, South Africa: Overview Paper

5. Stakeholder Analysis and Local Identification of Indicators of Success and Sustainability of Farming Based Livelihood Systems.

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1 SUSTAINABILITY AND INDICATORS

1.1 Introduction

The popularisation of the concepts of sustainability, sustainable agriculture and sustainable development has continued since the publication of the Brundtland Report (WCED, 1987). This is despite the lack of consensus regarding precise definitions and meanings. In more recent years, considerable attention has been focussed on the development of sustainability indicators, whether it be for sustainable cities, farming systems or manufacturing processes. This has included the development of strategies and plans for sustainable development from the local to national levels. In what might be seen as a slightly perverse development, researchers seem to have abandoned attempts to define sustainability and now often seek to simply measure it.

Despite the effort now being devoted to the development of sustainability analysis and of indicators of sustainable systems by a number of national governments, international and national bodies as well as individual researchers and practitioners, there is a shortage of literature which summarises the developments, approaches and frameworks used. Though a recent book by Bell and Morse (1999) attempts this.

This working paper attempts to provide a background guide to those involved in the development of indicators of sustainable systems with a particular focus on natural resource management. It originated from the need to develop and measure indicators of successful and failing farming systems as part of a research project funded by the UK Department for International Development (DFID). This project, entitled 'The effects of policy and institutional environment on natural resource management and investment by farmers and rural households in east and southern Africa', is implemented by 5 research institutions in the UK, Uganda and South Africa[5]. In this context the paper is particularly concerned with issues and approaches related to the development of indicators of successful farming systems and rural livelihood strategies. However, the discussion of these specific aspects of sustainability indicators is accompanied by a review of indicator frameworks which has a wider, and more general relevance.

1.2 Background to sustainability indicators

The search for sustainability indicators for renewable natural resource management, and in agriculture and rural development in particular, has its origins in the sustainable development paradigm. Almost as well known now as the definition of sustainable development presented in the Brundtland Report (WCED, 1987) is the fact that sustainability means different things to different people and that there is no consensus on its precise or operational meaning.

Brundtland famously defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987:43). Their have been a seemingly endless array of definitions produced since Brundtland, and there will no doubt be many more in the future. However, the definition above certainly highlights one of the key aspects of sustainability which is the

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concern over the impacts on future generations of actions taken today. This focus on *Intergenerational Justice* is certainly one of the defining features of sustainability. Another aspect of Brundtland and sustainability, one which sometimes receives considerably less attention, is the issue of *Intragenerational Justice*. Hence the WCED report also concluded that:

“it is both futile and an insult to the poor to tell them that they must remain in poverty to protect the environment” and that “problems of poverty and underdevelopment cannot be solved unless we have a new era of growth in which developing countries play a large role and reap large benefits.”

Writing on the proliferation of definitions of sustainable development, Pezzey commented that he saw “little point in expanding the collection of fifty sustainability definitions which I made in 1989, to the five thousand definitions that one could readily find today” (Pezzey, 1997).

Such a lack of consensus on meaning and surfeit of definitions has lead some to argue that sustainability is a meaningless concept. Temple (1992) states that “the overuse of the word has meant that it has come to mean too much and nothing at the same time and as a concept is too largely drawn to have any particular usefulness.” Daly wrote that “sustainable development is a term that everyone likes, but nobody is sure of what it means (at least it sounds better than ‘unsustainable development’)” (1996: 2).

Rigby and Càceres (1997) write on this issue that:

“This raises the possibility of sustainability being considered so vague a concept that it has little meaning and should be discarded. This issue is considered in a more general form by Jacobs (1995). Noting that there are at least 386 definitions of sustainable development, and that both Mrs Thatcher and Friends of the Earth have signed up to it, he asks if it is meaningless. Jacobs answers ‘no’ because: ‘...this is to mistake what it means for a political principle to be meaningful. There are far more than 386 definitions of democracy, but that doesn’t mean the concept is meaningless. Nor does the fact that different people disagree on what counts as democracy. Key political principles like democracy...are contestable -they are open to different interpretations- but they carry a core meaning...which is substantive and important.’ (1995:9) (1997:27)”

This is a view we share. Suffice it so say that the entering of the term into common language has meant that for many people sustainability has some meaning, even though that may vary across time and between individuals. Moreover, the different interpretations held by those with different perspectives, agendas and priorities can themselves be revealing and provide insights. We will argue in this paper that the development of sustainability indicators is extremely useful in this respect, in that it pulls the discussion of sustainability away from abstract formulations and encourages explicit discussion of the operational meaning of the term (see Rigby *et al.*, 1999 for more discussion of this).

It is worth noting, as Pearce comments, “that some people do *not* want measures of sustainability. Indicators might show them up in a bad light, in which case it is always better to say that sustainable development is a fuzzy concept and has many meanings, but is, of course, something we all support. If indicators develop in particular ways, they may also force decision-makers to address questions they prefer not to address, for example, the real, underlying causes of environmental degradation rather than the cosmetic causes which can be addressed and for which, perhaps with adequate 'spin doctoring', good publicity can be obtained.” (1998:5).

1.3 Sustainability Indicators and Natural Resource Management

The “adoption” or pursuit of sustainable development, and indicators of sustainability, accelerated following the Earth Summit in Rio in 1992. One outcome of the Earth Summit Conference was the creation of the Commission on Sustainable Development (CSD) which was established to monitor the progress of sustainable development. This was to be done using a set of standards or indicators of sustainable development. A UN commitment was made to make indicators available to decision makers at the national level by identifying a set of indicators, defining a framework for their organisation, describing the methodologies required, testing the indicators in a national context and providing training regarding the use of the indicators (Luxem and Bryld, 1997). Thus, indicators were seen to be a vital tool for achieving the sustainable development goals established by Agenda 21.

Agenda 21 called for the development of, amongst many things, sustainable agriculture and land management as well as the systems necessary to monitor their achievement. This has led to a wide range of activities which have sought to define sustainability and, of particular relevance to this project, sustainable agriculture, land management and forestry (see Pretty, 1995 for comments on the number of different definitions since the Brundtland Commission). FAO have developed 40 methodology sheets on how to calculate indicators in the areas of agriculture, biological diversity, desertification, fisheries, forestry, freshwater, land use, and mountain ecosystems. Basher (1996) states that currently there is no general agreement on appropriate indicators and many countries are in the process of establishing environmental monitoring networks and testing potential environmental indicators (e.g. Kerr, 1990; Messer *et al.*, 1991; Hamblin, 1992; Doran *et al.*, 1994).

Most, if not all, of these initiatives have tended to be technically led. In relation to natural resource management this has led to a natural science view of sustainability and associated issues. For example, the Framework for the Evaluation of Sustainable Land Management (FESLM, Smyth and Dumanski, 1993) has, for example, been developed from a technical land management or soil science starting point. Alternative approaches have focussed on community indicators identified through participatory approaches. These have included the International Institute for Sustainable Development, (IISD) programme on Community Adaptation and Sustainable Livelihoods, CASL, in sub-Saharan Africa, and an International Institute for environment and Development (IIED) collaborative project in Brazil on participatory monitoring and output assessment of sustainable agriculture (Sidersky and Guijt, 1997). In relation to desertification, a workshop was held on the grassroots identification of sustainability indicators as early as 1992 (Hambly and Onweng Angura, 1995).

This review now focuses on some of the most relevant issues with respect to this development of indicators of sustainable systems, and the pertinent lessons for researchers and practitioners in this area. After a very brief explanation of indicators and thresholds, issues of time and scale are highlighted, different frameworks for organising indicator work are discussed and the different dimensions of agricultural sustainability commonly identified are outlined.

1.4 Different Understandings of what an Indicator Is

Although there is a rapidly developing literature on the use of sustainability indicators, there are different definitions of what an indicator is and different understandings of the primary roles of indicators. There are also varying opinions on the use of quantitative versus qualitative indicators, and on who is to identify indicators. Whether this should be by experts on scientific basis, or communities themselves on a more cultural and local knowledge basis, or through a combination of the two.

Gallopín surveys a wide range of literature and reports that in different sources an environmental indicator has been identified as "a variable…a parameter…a measure…a statistical measure…a proxy…a value…a meter or measuring instrument…a fraction…an index…something…a piece of information…a single quantity…an empirical model… a sign" (1997:14).

Smyth and Dumanski (1993) define indicators as "environmental attributes that measure or reflect environmental status or condition of change", Glen and Pannell (1998) argue that "an indicator is a quantitative measure against which some aspects of aspects of policy performance or management strategy can be assessed." This role of quantification assigned by many authors is not universally accepted, since some authors regard qualitative indicators (e.g. visual assessment of soil erosion) as valid tools.

1.5 Indicators and Indices

In general indicators are the result of the application of complicated functions to primary data. Indices are simple functions of lower-level variables (Gallopín, 1997). "the distinction between indices and indicators lies in the complexity of the function by which they are obtained, not in their hierarchical level" (Gallopín, 1997:16). This contrasts with the view of the Information Pyramid of Hammond *et al.* (1995) or Information Iceberg (Jesinghaus, 1998).

1.6 Targets, Thresholds and Goals

An indicator devoid of context has no value. Only in the context of a pre-specified value does it acquire meaning (Moxey, 1998). Such pre-defined values are often referred to as thresholds, targets and benchmark or reference levels (Gallopín, 1997).

A developing issue highlighted by several authors, including Coughlan (1996), Syers *et al.* (1995) and Izac and Swift (1994) is the importance of defining thresholds for indicators. Thresholds are boundary levels of a variable which is regarded on the basis of expertise to represent the point at which significant changes occur. "Thresholds are particularly important in an agri-environmental context given the propensity of ecological systems to 'flip' from one state to another" (Moxey, 1998: 14). Rennings and Wiggering argue that "target indicators like critical loads and levels should build the core of indicator sets for sustainable development" (1997:35) and Izac and Swift state that "the identification and quantification of such thresholds should receive a high priority in sustainability research as evidence concerning these thresholds is insufficient" (1994:120).

When an indicator passes this level then the system is considered to be unsustainable or on the road to unsustainability. Issues arise as to the identification of a threshold level (be it qualitative or quantitative) and who should identify this level: an expert view; a consensus of experts; or, views of local stakeholders and communities. A further issues is whether passing a threshold level for one indicator is sufficient to signify unsustainability, or whether several indicators need to have passed their threshold levels before the system is unsustainable.

Agreement on the identification of thresholds is not, however, universal. Glenn and Pannell (1998) reject the common view that thresholds exist since they argue that "there is no sense in which a sustainability indicator has a threshold level…the threshold indicator level for switching from one [management option] to the other is determined in an economic decision problem. This depends on the biological and physical relationships of the problem, but in no way can be divorced from economic considerations. Consequently it is pointless to attempt to determine threshold indicator levels based only on biological or physical criteria." (1998: 13)

Targets are concerned with intention. They are more directly located in the context of decision-making (at what ever level) than scientific expertise. They differ from goals since the latter are usually more general and qualitative, representing a general direction in which things are desired to move (Gallopín, 1997). The target is set in the context of the current situation, the threshold level and decisions made.

1.7 Desirable Properties of Indicators

Definitions are numerous, and it is perhaps more useful to identify the uses and desirable properties of indicators. Following Tunstall (1992, 1994), Gallopín (1997) identifies major functions of indicators as:

- to assess conditions and changes;
- to compare across place and situations;
- to assess conditions and trends in relation to goals and targets;
- to provide early warning information; and,
- to anticipate future conditions and trends.

In their development of Land Quality Indicators (LQIs) for the World Bank, Pieri *et al.* (1995) follow Adriaanse (1993) and Hammond *et al.* (1995) in identifying the following purposes of indicators:

- selection of the most significant information;
- simplification of complex phenomena;
- quantification of information, so that its significance is more readily apparent; and,
- communication of information, particularly between data collectors and data users.

The purposes defined above have largely been developed for use by "expert" users, whereas Guijt (1996) argues that good indicators should also be user derived, implying a more community or participatory involvement. She summarises a good indicators as those which are:

- policy relevant;
- user derived; and,
- highly aggregated.

Frequently, studies on sustainability assessment and the development of indicators produce long lists of indicators. These often reflect the number and technical background of those developing the lists, and tend to become lists of what people would like to know, and not necessarily need to know. It is therefore essential to keep the actual number of indicators to the minimum sufficient to reflect the different dimensions or aspects of sustainability (see Section C for discussion of these aspects).

1.8 Issues of Scale

The type of indicators constructed in any study and use will be influenced by the level at which the system is analysed. Indicators in studies such as this may be constructed at the plot, farm, village or community, district, catchment, region, agro-ecological zone (AEZ), or national level. For instance, the individual farmer will often be seeking, or will already have identified, an indicator which forecasts the yield of this year's crop based on a field or farm plot scale. Again at the farm level, the depth of soil may be a key indicator in assessing the sustainability, but at the national level it is impractical to measure the depth of all soils when it comes to assessing the agricultural systems at the national scale. Alternative or broader indicators are needed to achieve this. However, there has to be a link between the different levels. If we are using indicators to assess the relative sustainability of different farming systems we need to be able to relate this information and analysis to assessments at a "higher" level.

The decision about the level at which to collect information and apply indicators depends on both the issues being addressed and the data available. However as one moves up through the levels it may become more difficult to identify causal relationships, to identify desirable outcomes and to isolate choices that can be made with confidence. The decision at which level to collect information and apply indicators depends on both the issues being addressed and the data available. Pretty argues that: "At the farm or community level, it is possible for actors to weigh up, trade off and agree on these criteria for measuring trends in sustainability. But as we move to higher levels....to districts, regions and countries, it becomes increasingly difficult to do this in any meaningful way" (1995:11).

Greenland *et al.* argue that "much confusion in sustainability research derives from researchers studying different scales and then mixing levels in their analysis. Each level requires its own analysis to permit systematic scaling up or down between levels" (1994: 17). Following Lynam and Herdt (1992) and Izac and Swift (1992) they consider the farming system the most realistic level at which to operationalise sustainability. This has implications for the type of indicators that it is feasible to construct. Gomez *et al.* (1996) argue that working at the farm-level means that social issues cannot be incorporated. Given the range of levels at which agricultural systems can be defined, Lowrance *et al.* (1984) argue that "there is no 'correct' definition of agroecosystems since the research and management objectives determine the correctness".

The consideration of sustainability at different levels also concerns Pannell and Schilizzi: "the definitions employed in actual decision making for agricultural policies or research are often at an extremely small scale, such as the individual paddock. There seems no practical way to tell whether a farming practice which is apparently unsustainable by some local criterion is inconsistent with sustainability at the large scale" (1998: 4). They cite Graham-Tomasi who emphasises that:

"by focussing on overall well-being as the object of sustainability, it is not necessary, and may even be counterproductive, to insist on the sustainability of every component sub-system. ... Many analysts have been excessively concerned about the sustainability of particular components of an overall system, while ignoring substitution possibilities among components" (1991: 83-84).

This is particularly important in the context of agricultural systems. Izac and Swift note that "it may be perfectly acceptable for one part of the farm to be degrading during a particular time period, as long as the overall trend is positive. In traditional systems involving shifting cultivation or rotation this is exactly the mechanism employed" (1994: 110).

Graham-Tomasi's point relates also to aggregation. Indicators may be constructed at many different levels, but care needs to be taken when attempting to combine them. This is generally acknowledged, but Graham-Tomasi's point is that the sustainability of all the individual component parts of a system is not a necessary condition for the system's sustainability.

The level at which indicators are constructed has implications for the type of indicators that it is feasible to construct. As explained above, Gomez *et al.* (1996) argue that working at the farm-level means that social issues cannot be incorporated, whilst Müller (1996, 1998) excludes social issues at the plot level but includes them at the farm household level.

There is no prescription here regarding what is the appropriate level for the measurement of indicators in a particular study. In relation to the research of this project, the emphasis on the investment decisions of farm households of differing scales and success indicate that the farm/farm household are likely to be the focus of attention, but probably not to the exclusion of assessment at the plot as well as higher levels of scale (village, region). Different types of indicator are likely to occur at different levels of scale. However, we expect the measurement of certain types of indicator (see, for example, driving force or pressure indicators in Section B) to take place at levels above that of the farm household. So driving forces and pressures in the region (population change, increasing competition for land etc.) will shape the livelihood strategies of individual households.

This issue of scale should be borne in mind throughout the development of any study's indicator sets.

1.9 Internal (Community) and External (Expert) Indicators

A key question when working with sustainability indicators is who identifies the indicators and on what basis. In the context of this particular project it is seen as useful to identify two sets of indicators: those identified by "external" experts, such as the project researchers; and, those "internally" identified by the different stakeholders in the systems themselves. The latter group would include farmers, households, communities, and local agencies (e.g. District office of Department of Agriculture, or NGOs). When considering this division between the role of "external" researchers and local "community" members, it is worth noting that there is also a separation here between *issues* and *indicators*. A key issue in the success or otherwise of a system (for example, the maintenance of soil fertility) may be agreed upon by both researchers and community members. However the indicator which each group uses to monitor the issue may differ. Alternatively, it may be the case that the key criteria on which the success or failure of the system is judged differs between researchers and community members, in this case the both the key issues identified (and the associated indicators) are likely to be different.

It may also be the case that one group may consider a system to sustainable, whereas another group using another set of criteria and indicators judge a system to be unsustainable. It therefore becomes problematic as to which is the correct criteria and set of indicators to use. This relates to an issue raised at the beginning of this paper on the varying definitions on the meaning of sustainable development (or sustainable natural resource management). If a consignees cannot be reached then it is important to identify these varying views or perceptions, particularly if we are looking to influence management and policy decisions on the way to promote more sustainable use.

1.10 Cross-section or Time-Series Analysis ('State or Rate')

Another major issue to be considered when choosing and measuring sustainability indicators is whether indicators are to be constructed and monitored between sites at a single point in time, monitored over time, or both. Ideally indicators of both types should be measured.

A fundamental issue is time. We want to know what has and is changing. With a focus on farming systems this requires an understanding of what has happened to the biophysical environment, how have people's perceptions and management and livelihood strategies changed, how have policies and institutions changed, and how have these affected each other? However, monitoring over time is more problematic, as information from external sources is generally required.

If trends over time are to be determined then there are two alternative sources of information which can be used. The first is the possibility of using secondary historical sources (public records, resource surveys, aerial photographs and satellite images, farmers' and extension agents own knowledge, past academic studies etc.) as a point of comparison and possible trending. If these secondary sources consist of only a one-off observation then any trends inferred can only be linear and used with some caution. In addition Moxey notes that great care must be used when using such secondary sources since "data from different sources often have slightly different definitions, even when supposedly describing the same thing" and “different data items from different data sources are often reported for different spatial…frames and scales, making their collation and combination difficult” (1998: 11).

Sources of this additional information may be categorised as:

1. Historical sources which may include:
   - *Secondary historical information* - past records; studies and surveys.
   - *Community and individual recollection*.

2. Biophysical information from sites which were previously of a similar type to other study sites, but have been cultivated or otherwise used in a different manner over a recent, known time-period. In this way measurements taken at the same moment in time can be treated as observations at differing time points. In this way, a *baseline* site can be paired with other sites.

A third set of ‘observations’ is possible if projections, model simulations or something similar are used to try to identify future values of relevant variables. These can range from the use of extremely complex agri-environmental models such as the Erosion Productivity Impact Calculator (EPIC, see Sharpley and Williams, 1990) and CENTURY (see Parton *et al.*, 1983). to very approximate ‘guesstimates’ of future states. The former is extremely unlikely to be feasible in this study, the latter is always an option but carries with it the problems of lower confidence in the trends that result.

It is instructive to consider examples of work in the areas of indicators of sustainability relating to agricultural systems and land quality. However, before some of these examples are reviewed it is instructive to step back a little and consider some of the various indicator frameworks which are often used to organise work of this kind.

2 INDICATOR FRAMEWORKS

2.1 Background

Several sets of methodological frameworks or guidelines have been identified for the measurement of sustainability indicators at the farm or community to district levels. These have all tended to come from an approach focussed on sustainable agriculture and/or sustainable land management – often directly related to the FESLM. These have included: the guidelines for conducting case studies under the FESLM (Dumanski, 1995); Protocol for conducting case studies under the FESLM (Bechstedt and Renaud, 1996); and Guidelines for Impact Monitoring (CDE). Other relevant frameworks are those on sustainable livelihoods and poverty assessments. For example, UNDP is also developing a framework for poverty assessment and associated indicators (UNDP, 1999).

The United Nations, World Bank, OECD, European Environment Agency (EEA), IBSRAM and many other organisations and national governments are currently producing indicators or proposed indicators of sustainable development and sustainable agriculture. The frameworks within which these methodologies and indicators are being proposed differ. Some are developments of previous frameworks, but their frequent use is a recognition that a conceptual framework is required to organise indicators:

"Indicator frameworks, organising individual indicators or indicator sets, in a coherent manner, have several additional uses. They can guide the overall data and information collecting process. They are useful tools to decision-makers, summarising key information from different sectors. They suggest logical groupings for related sets of information promoting their interpretation and integration. They can help to identify data collection needs. Finally, indicator frameworks can help to spread reporting burdens, by structuring the information collection, analysis and reporting process across many issues and areas that pertain to sustainable development." (UNEP-DPCSD/Ghent Report, 1995: 6).

In addition to the various frameworks used, there are differing dimensions, aspects or properties of sustainable agricultural systems that are proposed as criteria for sustainability assessment.

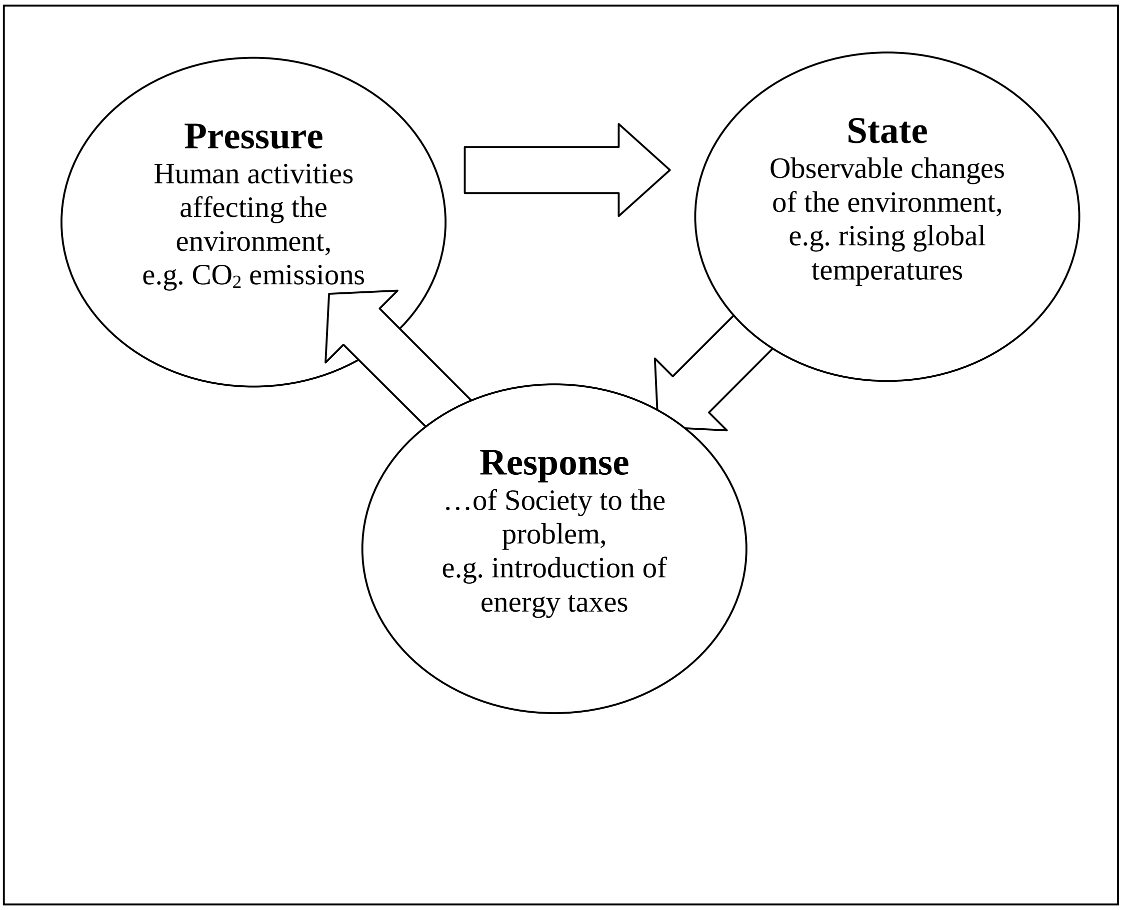
2.2 Pressure-State-Response Framework

The PSR framework, illustrated in Figure 1 (from Jesinghaus, 1998), was developed from the stress-response framework which was applied by Friend and Rapport (1979) to ecosystems. This framework is used by OECD, SCOPE (Scientific Committee on Problems of the Environment) and some other organisations working in the field. The PSR framework is the most widely accepted of the many frameworks advocated (Jesinghaus, 1998). Having been adopted by the OECD for its State of the Environment (SoE) group, the European Commission's indicator development also uses the PSR approach. The PSR framework was the framework used in the 'Environmental Indicators – OECD Core Set' document (OECD, 1994) and is also used in the methodology of the World Bank's Land Quality Indicator (LQI) programme which makes use of the 5 Pillars of Sustainable Land Management (discussed in Section C below).

Pressure refers to "human activities that exert a pressure on the environment and change its quality and the quality and quantity of natural resources (the 'state'). Society responds to the changes through environmental, general economic and sectoral policies (the ‘response’). The latter forms a feedback loop to pressures.” (Gallopín, 1997:22). These pressures are considered to be negative.

The OECD acknowledges that the PSR framework has an implicit notion of causality within it since it “tends to suggest linear relationships in the human activity-environment interaction” (OECD: 1993: 5). Unhappiness with this idea that (negative) pressure causes changes in the environment which prompts society’s responses is one of the motivations for the development of the driving force-state-response (DSR) framework now discussed.

Figure 1 The PSR Framework



2.3 Introducing Driving Forces and Impacts into the PSR Framework

Some organisations prefer variants of the PSR model; for example, the UN Commission for Sustainable Development (UNCSD) bases its indicator set on the Driving force-State-Response model (DSR) model, which allows for a better inclusion of non-environmental variables (UN CSD, 1996). The replacement of the term "pressure" in the PSR framework by the term "driving force" was motivated by the desire to include economic, social and institutional aspects of sustainable development.

This adjustment was deemed necessary when one shifts from a consideration of environmental indicators to these indicators plus the state of the human subsystem. (Gallopín, 1997:22). The extension of the focus to all aspects of sustainable development (social, economic, environmental and institutional) is argued to be "particularly important for developing countries…for whom an equal balance between the developmental and environmental aspects of sustainable development is important in order to ensure future sustainable growth patterns" (1997: 49).

Another aspect of the DSR framework which separates it from its predecessor is that there is no assumption of causality between indicators in each of the categories.

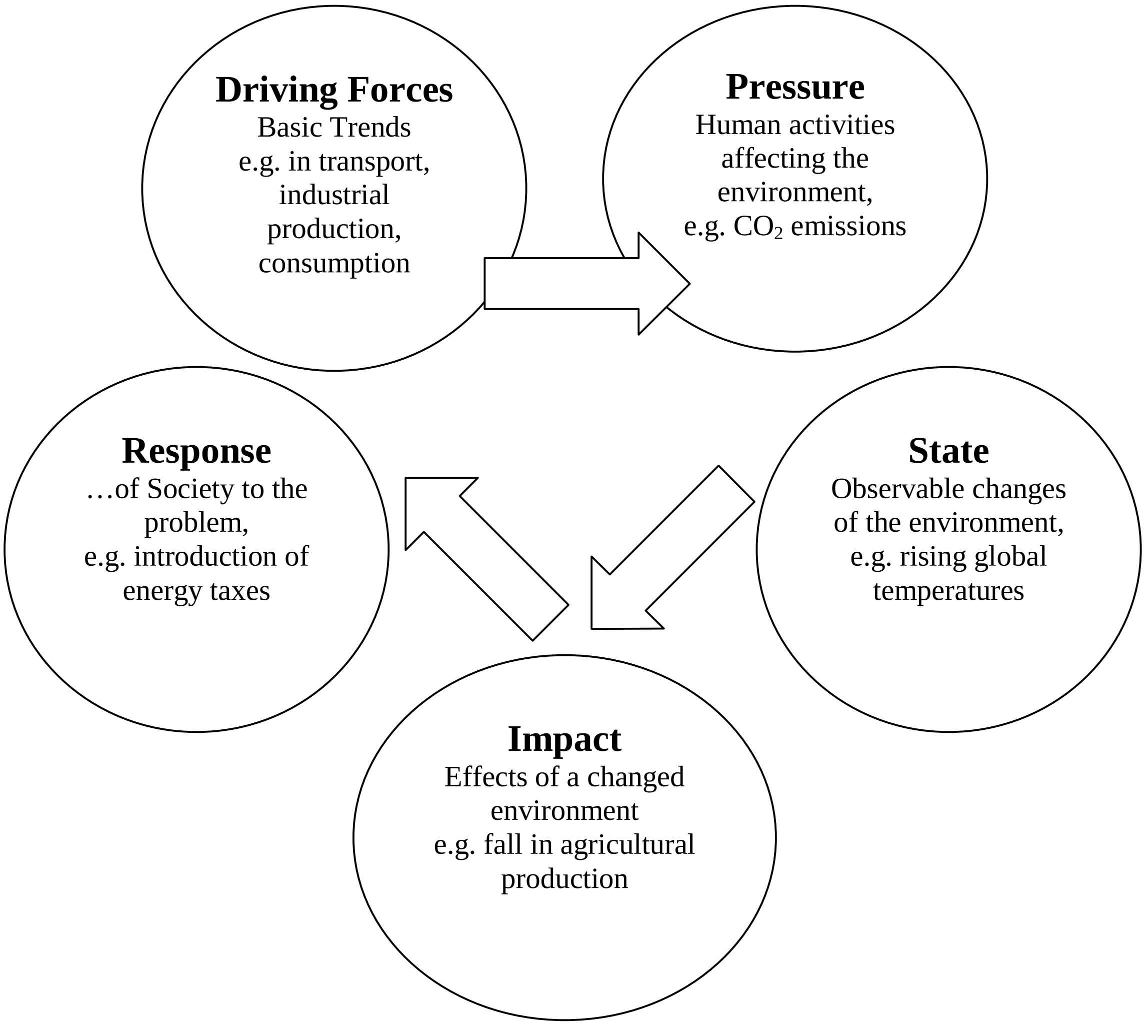
"The term 'driving force' indicates…an impact on sustainable development. This impact can be both positive and negative, which is not the case for the pressure category used by the OECD". (Mortensen, 1997: 48-49). "Driving force indicators represent human activities, processes and patterns that have an impact on sustainable development" (Mortensen, 1997: 47).

The World Bank adopted the DSR framework in its work on indicators of environmentally sustainable development (World Bank, 1995), although in 1997 it published 'World Development Indicators' (World Bank, 1997) which used the PSR framework.

For a better description of underlying economic trends, some authors have formulated the Driving force-Pressure-State-Impact-Response model, which includes PSR and DSR as special cases (Jesinghaus, 1998).

In the DPSIR framework State and Impact indicators are separated. State indicators show the current condition of the environment. Examples include the concentration of lead in urban areas; the noise levels near main roads; the global mean temperature. Impact indicators describe the ultimate effects of changes of state. Examples include the percentage of children suffering from lead-induced health problems; the mortality due to noise-induced heart attacks; the number of people starving due to climate-change induced crop losses.

Figure 2   The DPSIR Framework



3 PILLARS, DIMENSIONS OR ASPECTS OF SUSTAINABILITY

3.1 Dimensions of Agricultural Sustainability

Despite the contested nature of sustainability, there is agreement that it is multi-faceted, and therefore the (un)sustainability of systems must be assessed over several dimensions. Pannell and Schilizzi (1997) argue that it is the ambiguous and mutli-facteted nature of sustainability that has led to the proliferation of sustainability indicators. At its simplest, the multi-faceted nature of sustainability is often accounted for by just considering the economic, social and biophysical aspects of a system.

Some differing approaches to the different dimensions or aspects of sustainability are discussed below. Again the focus is on agriculture and land management systems. To conclude the section some issues relating to the uses and users of indicators, which should be considering when designing indicator sets, are discussed.

The Framework for the Evaluation of Sustainable Land Management (FESLM), being used in the LQI programme of the World Bank, identifies the 5 pillars of sustainable land management as:

- *Productivity* - maintain or enhance production services.
- *Security* - reduce the level of production risk
- *Protection* - protect the potential of natural resources and prevent degradation of soil and water quality
- *Viability* - be economically viable
- *Acceptability* - be socially acceptable

It can be seen that some of these pillars will be more related to either economic, social or biophysical issues.

Müller (1996, 1998) develops Conway's (1987) work on the properties of agroecosystems to produce criteria for the assessment of agricultural systems. Conway's properties of agroecosystems (productivity, resilience, stability and equity) are amended to become the following criteria or dimensions identified by Müller:

- Efficiency
- Resilience and biodiversity
- Rules for natural resource management
- Basic life support functions
- Satisfaction of basic needs

3.2 Examples of Indicators of Agricultural Sustainability

Despite the proliferation of literature on sustainability indicators, there are few actual examples of published applied work where indicators have been used at the farm or local level. Direct enquiries we have made with a wide range of organisations (e.g. World Bank, IISD, ACIAR, and CGIAR Secretariat) and individuals has confirmed this. Two examples where indicators have been used are discussed below.

Gomez *et al.*(1996) construct farm-level indicators using the FESLM approach. The indicators are applied to 10 farms in Geba, Cebu, Philippines. Six indicators are used, five are concerned with biophysical factors with profit as the final indicator. The six indicators used are:

- Yield
- Profit
- Frequency of crop failure
- Soil depth
- Organic C
- Permanent ground cover

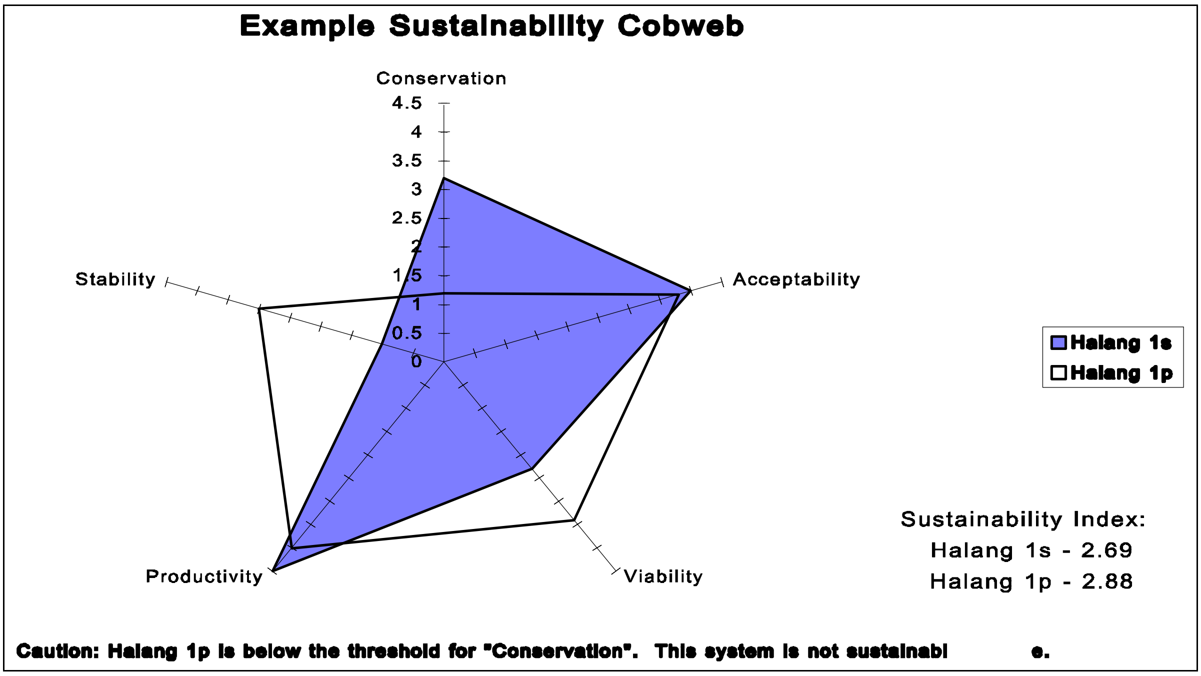
As noted above the five pillars of FESLM include 'social acceptability', but the authors note that this "has more relevance at the community level parameter and is not included at the farm level" (1996: 404).

This paper is also noteworthy since it employs sustainability polygons/webs to illustrate graphically the relative sustainability of systems. Simultaneously displaying a number of indicator "scores" in this way avoids having to aggregate across different scales (i.e. having to aggregate profitability and organic carbon levels). The threshold levels used for all the indicators are based on the average in the community.

Such sustainability webs appear in Swete-Kelly (1996), Figure 3, Bockstaller *et al.* (1997) and Rigby *et al.* (1999)

Müller (1996, 1998) reports the results of the development of indicators of sustainable agriculture in the Rivento River Watershed in Costa Rica. In doing so a detailed methodology is developed regarding issues of scale and the dimensions of sustainability that should be assessed.

<u>Figure 3. Swete-Kelly's (1996) Use of Sustainability Cobwebs</u>



The framework used comprises three levels of scale: plot, household, watershed. Indicators are categorised as being of three types: economic, social, environmental/biophysical. The five criteria or dimensions identified earlier are used to determine the sustainability of systems, with different sets of these dimensions for different scales. The matrices that appear in the resulting analysis are of the form:

PLOT LEVEL:

	Env/Biophys	Economic
Productivity		
Efficiency		
Resilience		
Rules for Resource Management		
Biodiversity		

FARM HOUSEHOLD LEVEL:

	Env/Biophys	Economic	Social
Productivity			
Efficiency			
Resilience			
Biodiversity			
Satisfaction of Basic Needs			

WATERSHED LEVEL:

	Env/Biophys	Economic	Social
Productivity			
Efficiency			
Resilience			
Biodiversity			
Satisfaction of Basic Needs			

Rigby *et al.'s* (1999) study differs a little from those discussed above in that it uses data collected for another purpose to construct a farm-level indicator of agricultural sustainability. The dataset comprises 83 organic and 154 conventional horticultural producers in the UK. The 3 facets of agricultural sustainability identified are:

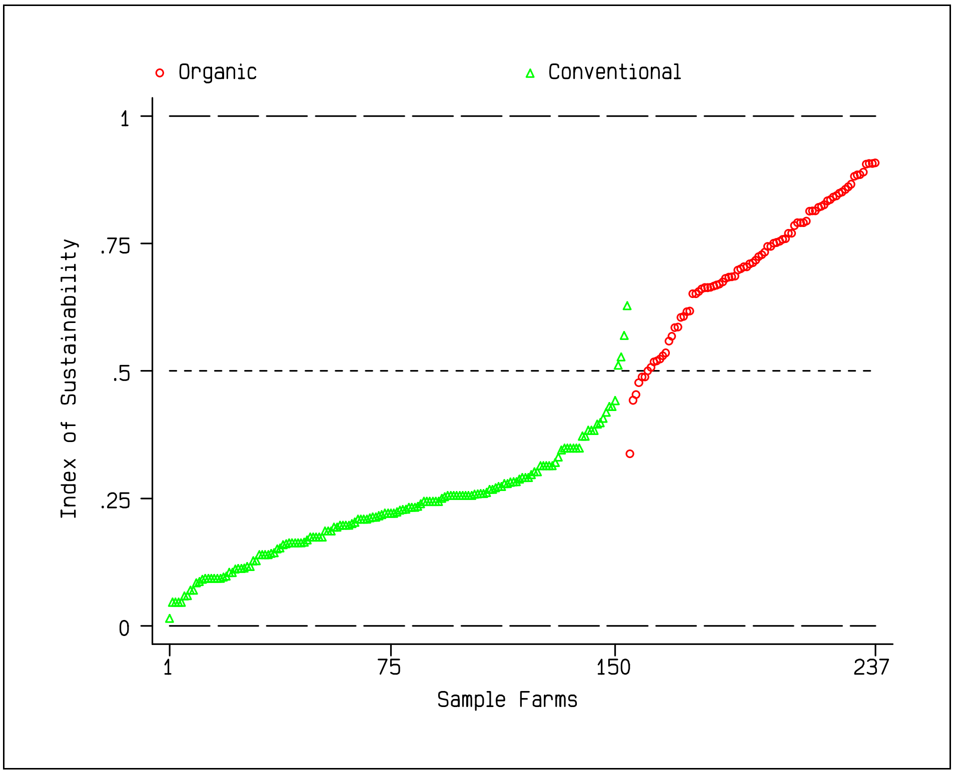
1. Improved farm-level social and economic sustainability
    - enhance farmers' quality of life
    - increase farmers' self-reliance
    - sustain the viability / profitability of the farm

2. Improved wider social and economic sustainability
    - improve equity, 'socially supportive'
    - meets society's needs for food and fibre

3. Increased yields and reduced losses while
    - minimising off-farm inputs
    - minimising inputs from non-renewable sources
    - maximising use of (knowledge of) natural biological processes
    - promoting local biodiversity / ‘environmental quality’

The data available to the authors allows the construction of an index which only relates to the third aspect of sustainability identified above. In particular farms are classified according to their input use strategies with respect to seed source, pest/disease control, weed control and the maintenance of soil fertility. A particular feature of the index used is the differential scoring of synthetic chemical inputs within the index, with pesticide use generating a far great negative ‘score’ within the index in comparison to inorganic fertilisers. The range of index scores (the index is subject to a linear transformation to lie between 0 and 1) is shown in Figure 4.

Figure 4. Index Values Split by Organic and Conventional Farm Type



While the studies of Müller, Gomez *et al.* and Rigby *et al.* described above are examples of indicator development, the paper by Izac and Swift (1994) offers a framework for the generation for the measurement of sustainability for small scale farming in sub-Saharan Africa. The motivation for this is the view of the authors' that sustainability "has remained largely inoperative in applied research in SSA" (1994: 106). The village agroecosystem is identified as the relevant social and spatial unit of analysis and, it is argued, a meaningful test of sustainability is whether this unit provides non-declining trends in resources and amenities for at least ten years.

3.3 Purpose and users of indicators

It is useful to look at the purpose of the measurement of indicators at the farm or community level. Why is a set of indicators to be measured, and how will the information they provide be used? Another important consideration often neglected is who is to be the user of these indicators? An example of the possible purposes of indicators identified by research staff in the Pacific are given in Box 1.

Examples of work linking indicators to policy and institutional development at the farm, community (village) or district levels are rare. Some exceptions are the work of Gomez *et al.* (1996), Gameda and Dumanski (1995), Müller (1996, 1998). Hardaker in his review for FAO of farm level information for policy making for sustainable agriculture and rural development discussed the issues surrounding this (FAO, 1996), but this has yet to be operationalised (Hardaker, pers comm).

Box 1 Purpose of the use of indicators at the farm level (Source: Howlett, 1996)

- To develop capacity and commitment of farmers towards more sustainable land use, and to allow farmers to evaluate their own practices.
- For the simple diagnosis of problems and improvements to farming practices, and development of appropriate research and extension activities.
- To enhance (or improve) the relationship between the researcher, farmer and extension agent, and through this to encourage farmer participation, the incorporation of indigenous knowledge, and ultimately to an increase in the adoption of improved technologies.
- To assess and monitor the spatial and temporal sustainability of different farming systems, and to use this for the evaluation, prediction, planning and management of these systems by farmer, researcher, extension agent and planners.

Much of the measurement of indicators has, at the end of the day, largely resulted just in the measurement of indicators. The actual operationalisation of indicators to influence or change, for instance, policy is still in its infancy. This includes some of the actual examples discussed in this review. For instance, the work in the Philippines (Gomez et. al. 1996) focussed on identifying indicators of sustainable land management between adopters and non-adopters of conservation practices. A valid exercise in its own right, aimed at assessing the degree to which indicators could be rapid, reliable, practical and inexpensive enough so as to be useful to practitioners. However, the development of practitioner–orientated indicators is very much in its infancy, with different indicators and frameworks in the process of being developed and tested. The usefulness of such indicators to farmers, extensionists, researchers or policy makers in the development of more successful and sustainable farming systems and livelihoods has yet to be determined.

Other measures of sustainability or closely related issues have tended to focus on a single perspective or issue. For example, Stocking's (1995) recent work on the rapid appraisal of land degradation looked at a specific part of the sustainability equation – soil erosion. Similarly, the work of Müller looked at indicators of sustainable agriculture but with a specific focus on the use of agro-chemicals (their minimisation an apparent objective behind this project).

Views differ as to whether indicators should be identified "externally" by scientists, economists or "internally" by local communities themselves. One view sees sustainability defined from the "top" with the imperative to maintain and conserve the renewable natural resource base for future generations (e.g. FESLM). A second view focuses on the participatory and empowerment paradigm where local communities need to define what is sustainable to them and to then go on to determine the indicators for this sustainability (e.g. work of IIED and IISD). Both perhaps can be viewed as having some validity.

For society as whole it is essential that renewable natural resources are used sustainably. For the local community or farmer it is also essential for sustainable and profitable natural resource based livelihoods that natural resource use is both successful and sustainable. One challenge, in relation to this project's research is to identify a set of indicators which will yield useful information about the status and rates of change in the full range of assets managed by individuals, households, and businesses and that are relevant to both planners and resource users. An important aspect of the choice of indicators will therefore be to identify at least a core set which will allow comparability across different study sites.

4 ACKNOWLEDGMENTS

The authors would like to acknowledge the support of their respective institutions in undertaking this work, and the financial support of DFID to this research project. However, all statements and opinions are those of the authors, as are all omissions and errors.

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