The Development of Ecological Performance Indicators for Sustainable Systems

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ABSTRACT

Agricultural producers are interested in improving the sustainability of their farming systems. There has been a proliferation of benchmarking schemes to aid producers, with some resultant confusion in the mind of end users. These schemes usually emphasise financial and some biophysical indicators, but have less useful sustainability criteria. Sustainable systems need to incorporate an analysis of economic, ecological / environmental and social factors to define a more appropriate, optimal path. We are really only just starting to do this. This paper will discuss an approach to determining ecological performance indicators that can be used to manage farming systems more sustainably.

Key words

Ecological, performance, indicators, sustainability.

INTRODUCTION

Improving the sustainability of agricultural enterprises in Australia has become a major concern. Market pressures force many producers to seek short-term gains that often result in longer-term problems such as salinity, acidity and loss of biodiversity. In turn, these insidious and often permanent changes to the environment become community problems because they have impacts beyond farm boundaries (SCARM 1998). More sustainable farming systems are desirable but we are still trying to define what constitutes a sustainable practice and how to assess when you have attained it.

The current definition of ‘sustainability’ is now very broad. It can be considered within a 4-D framework where the axes are: financial, ecology / environment, social and time. For any given circumstance the optimum combination of factors will vary and to be workable, probably exists within some boundary conditions rather than at any fixed point. Within the sustainability context, ecological / environmental components have had limited development even though these are arguably the key to a rational assessment of the long-term biophysical performance of a farming system. This paper aims to consider the current approach for defining ecological / environmental indices for agriculture and how they may be further developed to better reflect sustainability. Emphasis is on indicators at a farm rather than regional level because it is only within the confines of the farm where management can effectively maintain environmental integrity.

SUSTAINABILITY COMPONENTS

As a prelude to discussing the ecological / environmental indices we will consider the 4-D sustainability model outlined above:

Financial indicators have always been used to assess the economic performance of an enterprise. Net profit at the end of the year is a common criterion (Dore, 1997) and this can be benchmarked as a return on capital invested and partitioned into the components of the enterprise that produce that profit. Most of these indicators are reasonably well understood.

Ecological / environmental i.e. biophysical indicators are not currently widely used and are less developed even though they are of considerable concern because they reflect the performance of a farming system over a much longer time-frame than is the usual case with financial indicators. Impacts need to be monitored both on- and off-farm to assess the overall performance and suitable indices are not available that can monitor change at different levels within ecosystems. Many of the indices that have been proposed as measures of sustainability are basically the tools used to monitor the technical performance of a crop or livestock system. While these provide good information on performance of an enterprise they provide at best a limited insight into the ecosystem and its condition.

Social indicators have received even less attention, but have become increasingly important as financial pressures increase and environmental degradation becomes more apparent. The impact of an enterprise on the local community can reflect back on the ability to operate with the educational level of managers often correlated with performance. The success or failure of an enterprise can also depend on a willingness of the farming families to accept living standards that are inferior to their city counterparts. A decreasing level of inter-generational transfer of assets is an emerging indicator of a reluctance of the next generation to accept lower living standards and hence of 'farming for the future'.

Time is included in the sustainability model being discussed here, as it is important to assess performance over the medium to long-term. Often enterprise or whole farm performance is only evaluated within a year, which is inadequate for the assessment of any fundamental underlying problems.

A survey of the performance indicators and benchmarks in current use (Worsley & Gardner, 2000) showed that there are many schemes in existence and producers could be forgiven if they were becoming confused. Among 66 different schemes it was evident that financial indices were well developed but other components of sustainability were less so.

CURRENT ECOLOGICAL / ENVIRONMENTAL INDICATORS

Various indices have been developed to assess the biophysical status of the system. These can be grouped as:

- land and water efficiency *e.g*. livestock units / ha & livestock units / mm rainfall (Dore, 1997),
- inputs of fertiliser and soil amendments as kg / ha,
- soil chemistry changes *e.g.* pH, organic matter & salt,
- diversity of crops grown (SCARM, 1998).

These indices have value, but they are not based upon an ecosystem approach. They are more focussed on estimating production efficiency, which may not relate to the longer-term sustainability of the resource base. In the case of estimating the diversity of crops grown, this appears to be based upon the curious analogy that more diverse ecosystems are more stable over time and thus a more diverse agriculture should be more stable? That analogy would depend upon how diverse the actual crops were *e.g*. annuals Vs perennials and the ecosystem structure within a paddock or farm.

Water use efficiency is often considered a reasonable guide to the sustainability of systems (Dore, 1997) as it may indicate higher rates of transpiration and less addition to water tables. However, that assumption doesn't always hold as non-growing plants still transpire water.

AN ECOSYSTEM APPROACH

An alternative way of developing biophysical indicators to assess the sustainability of agricultural systems, is to consider those systems as ecosystems and rethink what ones aims are. Agriculture operates within the context of ecosystems. Many of these ecosystems are very disturbed and the original flora and fauna have been replaced by introduced species, reconstructed into much simpler ecosystems. In all cases though, the objective is to convert some of the underlying resources into saleable plant and animal products. One's goal in agriculture can then be considered as '*harvesting products from the ecosystem*'. To do this efficiently requires that the integrity of the ecosystem be maintained so that you can continue to harvest from it. Ecosystem functions, such as nutrient cycling and keeping pest and beneficial organisms in some balance, need to be maintained. We can no longer view agriculture as if it were a factory system where all resources can be converted into products. There is abundant evidence even in our most productive farmland of landscape degradation where this ‘factory’ approach as been practiced for less than five decades.

Agriculture should therefore be seen as a *purposeful human activity system* that operates within the context of *balanced ecological systems.* Any disruption to the balance of that ecosystem implies that the agricultural system is unsustainable. On the other hand, an expected outcome of sustainable agricultural processes is the enhancement *i.e*. adding value, of the quality and, or quantity of the components of the ecosystem.

A suitable primary sustainability indicator would need to assess the relative pressure that the ecosystem is under to sustain the output desired. Secondary indicators could then explore components of the ecosystem such as the diversity of species (or functional groups) at each trophic level, chemical markers *etc*., which contribute to that primary indicator.

Established ecosystems are often in some form of dynamic balance where the inputs and outputs are similar. The maintenance of a balance between *e.g*. nutrients, water, energy *etc*., is thus critical for sustainable systems. From an agricultural perspective the inputs required to sustain production can provide a measure of the pressure on the ecosystem *e.g*. chemical, fertiliser and energy inputs per unit crop or animal product. Such indices may prove more useful than the measures of land and water efficiency used to date. Where the inputs required to sustain production are low then a low impact on the ecosystem is implied whereas a high level of inputs would imply greater risk of instability and of the system failing in the future.

The stability or resilience of ecosystems is a characteristic that we try to emulate in agriculture. This can be assessed from measures of ecosystem variability over time and from (time to and extent of) recovery after major perturbations such as a drought and fire.

Adding value. Performance indicators often try to assess the current state of the system and then set an appropriate benchmark. Of greater use in many agricultural contexts is the added value over time arising from improved practices, as many systems could be considered degraded. To be useful to producers, indices need to specify both the scale and direction of change over time.

The use of ‘value added’ could become more important in the future as society considers how to value the *ecological services* provided by agriculture. As argued by Binning *et?al*. (see Daily *et?al*. 2000) within twenty years, half of a farms income could come from the provision of such services rather than simply from crop and livestock production. Carbon credit schemes are already being developed. We will need to derive indices that capture these effects. An additional reason to develop more appropriate indices is to satisfy international standards such as ISO 14000 for environmental management systems (Geno, 1998). These standards can involve the concepts of continuous improvement *i.e*. adding value, as much as benchmarking against best practice.

Biodiversity. Biodiversity can be considered from two perspectives, first the implications for agricultural systems and second for nature conservation. It is generally accepted that more diverse ecosystems are more stable and potentially more productive. However, finding the right analogy for agriculture is not easy as most crop and pasture systems have few species and simple structures. Perennial species are important in ecosystems for maintenance of water, nutrient and energy cycles. It is suggested that the ratio of perennial to annual species on a farm would provide some measure of the ‘structure’ as would the areas of permanent pasture, annual crop, woodlands and wetlands. Ideally these areas should be rated relative to the original vegetation, though that is not an easy task. The proportions of pest plants and animals to useful species would provide a measure of the disturbance of the ecosystem.

A separate issue is the actual diversity of native species within a farm. This can be appraised directly by estimating the numbers of species (or functional groups) within various ecosystems. These measures primarily contribute to nature conservation goals. Unfortunately the benefits from some native organisms on agricultural systems are poorly understood and further work is needed to resolve those relationships and to determine those that should be monitored.

DISCUSSION

The assessment of sustainability requires a set of performance indicators that properly reflect the goals of an enterprise and for more sustainable systems. In the past emphasis has been placed upon developing production-focused indices, which do not take a full consideration of the ecological context within which agriculture operates. In this paper we suggest that rethinking the ecosystem context for agriculture can redefine the types of indices required. Some preliminary suggestions are offered.

The implementation of more useful indices also requires:

Hierarchical indicators. The proliferation of indices currently available has inherent dangers in that it can be difficult to decide which indicators are the more important and how best to use them. A preponderance of indicators on one aspect of an enterprise can create the (possibly) false impression that it is the most important aspect. Performance indicators need to be developed from a hierarchical perspective where a primary indicator assess the overall performance of that component and only if that is unsatisfactory do you then analyse the reasons for poor performance. The indicators chosen need to also be mechanistic *i.e*. the primary indicator is dependent upon secondary indices. Using a more mechanistic approach to deriving indices can then help determine those aspects of management that need to change. This includes making a proper interpretation of internal and external effects (Pannell *et?al*., 1999).

Indicators and management. Many indicators are derived from annual farm performance data. The improvement in farm performance requires that indices be incorporated into day-to-day management. Unfortunately this has not always happened and arguably led to the failure of many farm recording systems in the past (Hardaker & Anderson, 1981). The challenge is to derive indices that can be readily translated into appropriate management tools. Many of the current schemes do not have adequate follow-up and do not translate the results into changed management practices (Worsley & Gardener, 2000). A common issue often seems to be that indices are derived from annual returns often some time after critical management events have taken place. To justify the continuing use of benchmarking programs it will be important to provide managers with tools that can be used in their day-to-day management.

Common language. With the proliferation of schemes it is important that a consensus be developed for the terms used and the definition of those terms. There is usually reasonable correspondence among financial criteria, but less so when other aspects of sustainable systems are considered.

The components considered here are also relevant to the practices developed in other industries and the use of a ‘triple bottom line’ for accounting. We suggest that approach needs to develop further and to identify ways of linking each component into a single scheme. At present there are no accepted procedures for showing suitable links (SCARM 1998).

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