

The International JOURNAL

of ENVIRONMENTAL,
CULTURAL, ECONOMIC
& SOCIAL SUSTAINABILITY

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Agriculture

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VOLUME 2, NUMBER 3

INTERNATIONAL JOURNAL OF ENVIRONMENTAL, CULTURAL, ECONOMIC AND SOCIAL
SUSTAINABILITY
<http://www.Sustainability-Journal.com>

First published in 2006 in Melbourne, Australia by Common Ground Publishing Pty Ltd
www.CommonGroundPublishing.com.

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ISSN: 1832-2077
Publisher Site: <http://www.Sustainability-Journal.com>

The INTERNATIONAL JOURNAL OF ENVIRONMENTAL, CULTURAL, ECONOMIC AND SOCIAL SUSTAINABILITY is a peer refereed journal. Full papers submitted for publication are refereed by Associate Editors through anonymous referee processes.

Typeset in Common Ground Markup Language using CGCreator multichannel typesetting system
<http://www.CommonGroundSoftware.com>.

Sustainable Development in Australian Agriculture

Some Operational Issues

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Abstract: This conceptual paper examines some operational issues surrounding the notion of sustainability in general and in the context of Australian agricultural development in particular. It is argued that the greatest problem to be overcome in the realm of sustainable development is to devise a widely recognised definition incorporating the contemporary issues and concepts that have been established in the current literature over the last several decades. The paper has therefore placed greater emphasis on the definitional issues by reviewing the existing definitions and approaches towards measuring sustainable development. To this end the current literature has been reviewed in order to resolve the controversies towards proving a workable definition of sustainability in the context of the dynamic nature of 'sustainability' as an emerging issue of enormous significance. The main finding of this paper suggests that if policy makers cannot explicitly state the objectives of policy or management programs, there is little hope that definitions of sustainable development can move beyond broad, well meaning motherhood statements. Regarding the assessment of sustainable development it is proposed that a constant or rising Total Factor Productivity (TFP) – that is a value greater than or equal to one – indicates that the production system being considered is sustainable, providing service flows from natural resources are included as inputs.

Keywords: Sustainability, Australian Agriculture, Total Factor Productivity

Introduction and Background

THE CONCEPTS AND issues of sustainability and sustainable development are being frequently used and referred to in the academic and non-academic literature. While sustainable development may mean different things to different people, there is a need to arrive at a consensus as to what sustainability really means and more specifically what sustainability is all about. In general, it is viewed as societal attitudes regarding future generations' living standards and their right to inherit a natural resource base of non-decreasing value. It can be argued that progress in satisfying these attitudes will only be possible if practical and sensible constructs can be developed. At present in the literature, the number of definitions of sustainable development is large, many of which are essentially broad "motherhood" statements. To quote SOE (1996, p. ES-5), sustainable development aims "to meet the needs of the present without compromising the ability of future generations to meet their own needs." This definition is broad and unlikely to be challenged by many in the community. However, as an operational and implementable definition, values and concepts encompassed in this definition need to be developed. The aim of this paper is to provide a link between the motherhood statements regarding

sustainable development and a definition that can be used in a practical sense in the agricultural setting.

The outline of this paper is as follows. In Section 2, key concepts and issues of sustainability are presented. Section 3 is concerned with ideas, views and perspectives regarding a working definition of sustainable development for Australian agriculture. Section 4 is devoted to devising a working definition of sustainable development for Australian agriculture and finally Section 5 provides summary and conclusion, implications, limitations and future research potential in this area.

Literature Review

The Key Concepts and Issues of Sustainable Development

The issue of weak or strong sustainability and its implications for measurement has been raised and explored in the literature. Pearce (1998) has discussed how different interpretations of sustainability, either weak or strong, require different sets of indicators to be collected and analysed. However, the distinction between weak and strong is perhaps a little overplayed in the literature. King and Crosson (1995) have observed that the significant difference between weak and strong sustainability is the role of information. If it is felt that uncertainty



is important, then it is advised to take a position in line with strong sustainability. This effectively implies the implementation of the precautionary principle (Chisholm and Edwards, 1990) or the use of safe minimum standards. Randall (1987) proposed conserving resources at the level of a safe minimum standard, which is the stock of a resource that is just high enough to prevent irreversible losses, based on the precautionary principle. Moreover, Mullen (2002a) suggests that setting a safe minimum standard¹ is an explicit act of saving for future generations, but the risk is that future generations may not value the resource that is conserved as much as poor sections of the present generation. Hence, many advocates of safe minimum standards apply a caveat that the costs of the standard are not “too high”.

The definition provided in the SOE (1996) therefore appears to be unsatisfactory as a working definition of sustainable development. It would therefore be useful to refine our definition of sustainable development. The definition of King and Crosson (1995) is a good starting point.

“that the present generations leave future generations with the wherewithal -- the ‘social capital’, consisting of human, natural and physical (man-made) capital -- to create our kind of life or a life of at least equal quality to ours.” (p. 40)

Measurement issues aside from this definition assume that there will be an adequate stream of market and non-market goods and services. In turn, this requires maintaining all types of capital such as human, natural and physical (man-made) capital. This allows for the potential of substitution or offsetting of decline in priced values for unpriced values such as amenity services. In many ways, substitution has been at the heart of the debate about the relevance or otherwise of weak or strong sustainability. From an operational perspective, the important issue is the role of information. Information can in many ways be viewed as the most important form of capital as witnessed by the need to undertake this very study. King and Crosson (1995) recognise the importance of information in the following way;

“... ‘weak’ sustainability might be defined as a condition where the per capita stock of social capital is maintained over time by seeing to it that knowledge embodied in people (human capital), technology, and institutions is sufficient to permit substitutions among the

natural and built components of capital in response to changes in the demand for services of capital.” (p. 43)

Towards a Working Definition of Sustainable Development

In attempting to articulate a more functional and task orientated definition of sustainable development, it is necessary to keep in mind the functions and primary goals of those who are making use of the definition. For example, the Victorian Department of Natural Resources and Environment has a set of government strategic priorities (i.e. improve the quality of life of all Victorians) which are to be attained by the achievement of various specified outcomes (i.e. community satisfaction with stewardship of the State’s natural and cultural assets).² Without going into detail (see DNRE, 1996) the primary goal of DNRE is:

“To ensure sustainable development of natural resource-based industries, the protection of land and water resources and the conservation of natural and cultural heritage.” (p. 3)

A working definition of sustainable development must therefore take account of these goals. However, whilst it is necessary to move toward a working definition of sustainable development given the above requirements, this task is difficult to implement in practice.

The difficulty in being any more precise is neatly explained by Conway (1987) and Lynam and Herdt (1989). Both of these papers deal with sustainable development in the context of agriculture and as a result are of relevance to this paper. It is realised that an important question to be addressed is the specification of the boundaries of the system in question. Related to this is the issue of dynamic properties of the system. The issue of boundaries arises from the system level at which sustainability becomes a relevant feature. Too frequently in the literature there is a mixing of different system levels. Lynam and Herdt (1989) provide the following example;

“...a plant photosynthetic system is embedded in a plant system which is embedded in a cropping system which is part of a farming system, which is embedded in a regional or national agricultural marketing system which lies within the international market system.” (p. 383)

¹ In the traditional economic model, the safe minimum standard is imposed as a constraint seeking to maximising wealth by using resources efficiently. The change in wealth (shadow value) from relaxing this constraint provides an estimate of its cost to the present generation (Mullen, 2002a; p. 12)

² For more details see DNRE (1996).

As they rightly explain, except for the very highest system level, each lower system, except under quite special circumstances will be influenced by exogenous events. This observation follows from systems theory. Following Conway (1987), Lynam and Herdt (1989) therefore recognise that determining whether sustainability is an inherent property of the system or not, is crucial to defining sustainability adequately. Given all of the above, it is still necessary to at least move toward some sort of operational definition of sustainable development.

The evidence of history makes it easy to describe agricultural practices that were not sustainable. In reality, it is a much more difficult matter to prescribe practices that will be sustainable. As a result, definitions of sustainable agriculture have tended to define what it is not, rather than what it is. This problem of negative definition is added to by an increasing tendency for other terms both old (such as organic) and new (such as ecological, low-input) to be used interchangeably with “sustainable”.

A review by Lockeretz (1988) points out that ongoing confusion in terminology and definition may be due to a number of factors, namely:

- fundamentally different concepts of agriculture are involved in the different terms but authors do not always choose the correct terms,
- the various terms more or less cover the same concept but new terms are coined to avoid negative images that might be associated with older terms, and
- the term might be interchangeable in relation to particular practices, but not so in relation to fundamental concepts (e.g. crop rotation is a practice that rests comfortably in almost any agriculture, conventional included, however, other practices included with rotation may be in accordance with a particular fundamental concept).

Sustainable agriculture is an umbrella term:

“...a loosely defined term for a range of strategies to cope with several agriculturally related problems causing the increasing concern in the USA and around the world.” (Lockeretz, 1988).

Schaller (1989) has defined low-input sustainable agriculture in terms of its goals as:

“...an agriculture that is, and will continue to be, profitable for farmers, that will conserve soil and water resources and protect the environment, and that will assure adequate and safe food supplies.”

A similar observation was made by members of the American Society of Agronomy at the Society’s Annual Conference in late 1988:

A sustainable agriculture is one that, over the long term: (1) enhances environmental quality and the resource base on which agriculture depends; (2) provides for basic human food and fibre needs; (3) is economically viable, and (4) enhances the quality of life for farmers and society as a whole.

The discussions above cover a range of definitions and issues relating to sustainable agriculture that are largely couched in terms of agricultural practices. However, the concept of sustainability in agriculture has also been explored in some depth in the literature of agricultural systems and agro-ecology. For example, Conway (1985, 1987) described sustainability as the ability of an agro-ecosystem to maintain productivity when subjected to a major disturbing force. Marten (1988) distinguished between sustainability (resilience) and sustainability as the ability of farm management to maintain the production of an agro-ecosystem at a level greater than would exist without intervention.

At first sight, there would appear to be a considerable gap between sustainable development and sustainable agriculture. The former stems from a desire to maintain intergenerational equity, the latter from a desired characteristic of agro-ecosystems. The characteristic of sustainability of agro-ecosystem is an essential prerequisite for the achievement of the goal of non-diminishing intergenerational bequests of environmental assets. Thus, agricultural systems that are not resilient or that cannot maintain productivity will result in diminishing bequests. Under weak sustainability we could accept land degradation if at the same time we enhanced stocks of built capital.

It is acknowledged that a broad level of sustainability does not necessarily require agricultural sustainability. However, in this paper sustainable agriculture is defined as one in which land quality is maintained. Under weak sustainability, that land quality is readily substituted by other inputs.

In the light of the previous discussions, it is clear that the definition of sustainable agriculture can be modified to: “Sustainable agriculture is an agriculture that attempts, in the ways suggested by current knowledge and understanding to ensure that present use of agricultural land resources does not detract from its usefulness to future generations”.

The Operational Perspective of Sustainable Agriculture

An example of an operational perspective of sustainable agriculture is provided by the SOE (1996);

“Sustainable agriculture is based on the principles that: the supply of necessary inputs is sustainable; the quality of basic natural resources is not degraded; the environment is not irreversibly harmed; and the welfare and options of future generations are not jeopardised by the production and consumption activities of the present generation. There is a further objective, which is to maintain or improve yield.” (pp. 6-36)³

The above arguments point to the fact that sustainable agriculture is more a question of accepted principles rather than a single decision rule. Whether or not these principles yield an outcome that is economically meaningful is another matter. Furthermore, the principles which are used to describe sustainable agriculture become a matter of opinion and as such are open to challenge. A good example is provided by the various interpretations of the meaning of sustainable land use and land degradation. Harris and Fraser (1997) discuss the importance of soil degradation, how to evaluate its impact and what actually is a sustainable level of soil degradation. They conclude that this is an area of research in which there is a lack of consensus. Some researchers would argue that sustainable land use implies zero land degradation whereas others, such as Kirby and Blyth (1987) would argue that from an economic perspective there is in fact an optimal economic amount of land degradation.

“The optimal rate of land degradation may be either positive or negative, greater or less than the natural rate of land degradation, and will vary over space and time, particularly in response to changing economic and technological circumstances.” (p. 156)

Without continuing the debate about the appropriate way of characterising land degradation in terms of sustainable development, it is acknowledged that the concept is a dynamic process.

The Issues Associated with Developing an Acceptable Definition of Sustainable Development

Is it possible to devise an acceptable definition of sustainability? The answer to this question is in many ways related to the actual issue or problem being considered. To return to agricultural sustainability, what should drive an operational definition is the problem or resource management question under consideration. This means that broad motherhood statements can be used as guides to more specific

definitions of sustainable development that will be conditional upon the problem and/or situation being considered. For this approach to be practical, it is necessary that policy makers clearly articulate the problems and issues to be addressed.

We can move towards a more precise definition of sustainable development such as the one presented for sustainable agriculture. As is made clear in this context, the definition becomes a question of accepted principles. That said, this type of definition is to be preferred but it will in turn depend on policy makers being prepared to be explicit about the problems and questions they wish to see addressed. If policy makers cannot explicitly state the objectives of policy or management programmes, there is little hope that definitions of sustainable development can move beyond broad, well meaning motherhood statements.

It is also necessary to again make it clear that any discussion of sustainable development cannot ignore the role of existing institutional arrangements which provide the incentives and signals determining human actions (Wills, 1997). In many ways this is what has driven the agricultural policy adjustments in the European Union (EU) and the United States (US). The movement away from direct support payments for agricultural output, toward payments for the production of environmental output is an explicit recognition of sustainable agriculture.

Sustainable Development in the Context of Australian Agriculture

Agro-ecosystems are dynamic and subject to considerable change as system parameters change. Over time, it is likely that our knowledge and understanding of ecosystems will expand, new technologies and new products will be developed, consumer preferences and the characteristics of markets for agricultural commodities will change as will society's attitudes, and views about environmental issues. This highlights the difficulty with setting stable and long-term goals or objectives. Therefore, objectives should be couched in such a way as to accommodate change.

On the other hand, if the journey towards sustainable development in agriculture is to be fruitful it is useful to have an idea of the direction of travel, even if the eventual destination could change. Therefore, there is considerable merit in having both an idea of the direction of the changes that are needed at any point in time and a means of making some judgement as to whether progress is being made. This suggests not only the setting of priority objectives, but also the establishment of performance indicators, which reflect current views about both

³ SCARM (1998) provide a similar definition.

the direction and rate of change. Such indicators are important in focusing attention on achievable changes in agricultural business and resource management, in providing a means of measuring progress and as benchmarks against which to reassess policies.

The concern with natural resource management includes the potentially renewable resources of air, land (including soil and the diversity of plants and animals it is associated with) and water which are used in agriculture. This concern is based on the fact that agricultural practices can substantially modify the resource base. In some cases, this may result in higher productivity, fertility and stability associated with improved pastures. In other cases, higher short-term productivity may be associated with degradation, sometimes with long-term consequences, loss of species and habitats, loss of soil physical material on certain soils, contamination by chemicals which persist in the soil and some forms of soil salinisation are examples of long-term degradation which are either presently irreversible or are reversible only over many generations. Off-site effects are also important. Such degradation has the potential to reduce long-term productivity and profitability and limit the ability of future generations to produce agricultural commodities and to enjoy a rich and diverse environment.

Farming is first and foremost a business enterprise. In this respect, maintenance or enhancement of the agricultural resource base is as much a part of preserving the farm asset as the preserving or improvement of capital equipment or breeding lines. Using the resource base beyond its capacity is like any business using up its capital. Eventually it must reinvest or fold. Land degradation⁴ has a deleterious effect on the value of the farm, and influences the assessment of collateral by lending institutions. Maintaining the farm resource base will assist farmers to maintain their equity and this provides them with greater resilience when facing periods of crisis such as low prices or droughts. It is crucial for farmers to build sustainability permanently into their management strategies and not regard it as an issue, which only needs to be taken up when conditions are favourable. Equally, governments should also move quickly to provide the right policy and institutional framework for sustainable agriculture.

Associated with this is a need for effective farm management. Farm decision making is complex and strategies which aim to build in considerations of longer term resource maintenance, add to this complexity.

It is acknowledged that if it is in the farmer's interests to maintain the farm resource base, then why are we worried about sustainability? The problem arises because optimal use of land, even when considered over several decades, is likely to impose costs or externalities on future generations. If the present generation chooses to save for future generations then some policy response is required to more closely align the incentives of the present generation of farmers with those of future farmers (Mullen, 2002a).

Maintaining farm resource base does not mean that Australian agriculture will have to contract or close down. Agriculture can be expected to continue as a significant industry sector in Australia into the future and to develop in response to changing market conditions. Continuing economic viability is a vital element of sustainable development. Unless the enterprise is profitable, farmers will be less willing to institute a process of change and to meet extra costs in the present in adopting more sustainable practices. On the other hand, it must be acknowledged that a farm sector which ignores ecological and environmental issues will be at economic risk in the longer term and will continue to present a detrimental external impact.

Sustainable development in agriculture will mean that resource management issues need to be addressed in a wider and more integrated framework, with more emphasis on longer-term effects. The traditional approach of the policy maker in this area has been to focus on individual resource management issues. Thus, the problems have often been seen as, for example, soil erosion, salinisation or acidification when, in reality, they should be seen as integral parts of an overall farm system where the profitability of the farm and the condition of the resource base depend on the knowledge and management skill of the individual landholder. Greater weight must be placed on the achievement of environmental and social goals as well as economic goals, and on future as opposed to present consumption.

By its nature, agriculture modifies the natural environment and ecological systems. Resource management issues fall under broad categories; those which are associated with damage to or degradation of natural resources in-situ and those which are associated with off-site effects such as pollution. While there is some interrelationship between these groups (for example, soil erosion is a problem in-situ as well as the source of silt which causes turbidity in streams further down the catchment), the distinction is important because it has implications

⁴ Land degradation will only decrease land values if it decreases something of value to potential purchasers. Technological change can reduce the value of these land attributes. Moreover, farmers need to offset the potential value of these attributes with the cost of sustaining them.

for how sustainability problems are addressed and who has responsibility for particular problems.

Presumably, there are strong incentives for the present generation to solve off-site effects but the incentives to take account of in-situ degradation other than that which is in the interests of present farmers, are less strong.

Productivity and Sustainability

There exists a vast literature on measuring agricultural productivity, but very little of it has considered the role of productivity measurement in relation to sustainable development. However, of the literature that has considered this aspect, there are several proposed ways in which to proceed (see Ehui and Spencer, 1992 and Chisholm and Hone, 1996). Take for example Lynman and Herdt (1989) who have defined sustainable development in the following way;

“.. a sustainable system is one with a non-negative trend in measured output: a technology adds to sustainability if it increases the slope of the trendline.” (p. 384)

Similarly, the state of the environment (SOE) (1996) considered how crop yields might be used to assess sustainable development in agriculture. The rationale behind these suggestions is that crop yields integrate the effect of the many potential indicators of sustainable development. All impacts of agricultural production and natural resource use manifest themselves in final output and as such a focus on output can provide an alternative to considering a whole battery of separate indicators. In relation to Australia, Donald (cited in Hamblin and Kyneur, 1993) has considered wheat yields for every decade since 1860. The results suggest that, in the earlier period, farming practices were unsustainable but since about the turn of the century, yields (per unit area) have steadily increased. However, if the aggregate data is examined more carefully, these trends are not true of all areas in Australia. Indeed, in some areas yields have declined. For example, Hamblin and Kyneur (1993) attribute these declines to reduced soil fertility and intensive cropping practices. Decreasing yield could also be evidence of the agricultural system moving to a less intensive, more profitable, more sustainable longer term path.

Of more fundamental importance in relation to assessing sustainable development is the use of inputs to maintain or enhance output. Farmers can use compensating measures to overcome resource degradation problems (ie. input substitution) such as the loss of topsoil, or the loss of nutrients by using

other inputs to maintain output. Thus, any definition that does not take account of input use necessary to maintain or increase output misses much of the sustainability story. Hamblin and Kyneur (1993) note that in Australia as land is a cheap input into production, there has been a tendency to increase total production by using more land rather than by increasing output on the existing land. It is worth noting that the opposite is true for Europe where land is relatively very costly.

Furthermore, there is a problem in terms of the temporal dimension of sustainable development. It takes time for the impact of unsustainable land use to become obvious. The SOE (1996, p.6-36) provides a good example of the temporal scales that can be involved in such processes. Farming in Mesopotamia experienced an average yield decline of 0.1 per cent over 700 years which meant that irrigated cereal production became unsustainable and this is despite the adoption of new technologies such as salt tolerant crops. In relation to this example, however, it must be noted that over such a long period of time, climatic factors might well have played a significant role in the decline in yields.

Overcoming the Problem of Input Substitution

The question here is, how can we overcome the problem of input substitution when existing inputs are declining in quality in relation to assessing sustainable development? Various measures of input quality and quantity, along with output can be considered. We might for example choose a fundamental measure of soil condition (ie. water-holding capacity) and assess the impact of soil erosion. This type of information could be used in a simulation context to evaluate management options. Recently there has also been an interest in the use of soil macrofauna as an indicator of soil health (Lobry de Bruyn, 1997). But considering input indicators along with output yields is rather ad hoc. A more systematic approach would be to simultaneously consider both inputs and outputs.

In agricultural economics this has been achieved by employing Total (or Multi) Factor Productivity (TFP) indices. TFP is a measure of productivity and is defined as the change in the ratio of measured outputs to all inputs.⁵ The rate of productivity growth is generally expressed as a rate of change between time periods. In relation to the assessment of sustainable development it is proposed that a constant or rising TFP - that is a value greater than or equal to one - indicates that the production system being considered is sustainable. However, it is worth noting that TFP really means multi-factor productivity

⁵ Hone (1994, p. 26) gives a more detailed definition of productivity.

because in practice not all inputs are accounted for. This is especially true for some service flows from natural resources such as land.

The use of a measure of productivity as a means to assess the sustainability of agriculture has been supported in Australia (SCARM, 1998). SCARM notes that productivity measures such as TFP will reflect:

“the improvements brought about by changes in production efficiency and better production methods. From a natural resource base perspective, a positive rate of productivity growth would be associated with sustainable agricultural systems.” (p. 109)

The main problem with using agricultural productivity trends to infer sustainability is that it is difficult to ensure that all inputs have been accounted for. The service flows from the natural resource base are difficult to measure and even conventional inputs such as animal breeds, plant varieties and agricultural chemicals and fertilisers change in quality. Cultural practices and climatic conditions may also vary.

It is easier to hold inputs and practices constant in formal field experiments which are consequently a major source of information about the sustainability of agricultural soils (Byerlee, 1990). It is also possible to draw useful conclusions from farm statistics, using mathematical modelling to allow for changing levels of inputs. It is this type of analysis of yield trends in the Australian sugar industry, where sugar yields have remained approximately constant over 20 years despite increased potential yields from newer varieties, that has led to the conclusion that one input, the natural resource (soil base), may be declining in quality (fertility).

Summary and Conclusion

In this paper, attempts have been made to derive an operational definition of sustainable development that can be meaningfully employed to assess the state of Australian agriculture. As we note, our proposed measure, productivity, has previously been considered by Ehui and Spencer (1992), Chisholm and Hone (1996) in the assessment of sustainable development.

There are many alternative measures of productivity. The SOE (1996) suggested that crop yields might be used to assess sustainable development in agriculture. The rationale behind these suggestions is that crop yields integrate the effect of the many potential indicators of sustainable development. All impacts of agricultural production and natural resource use manifest themselves in final

output, and as such a focus on output can provide an alternative to considering a whole battery of separate indicators.

However, the use of inputs to maintain or enhance output is important in relation to assessing sustainable development. Farmers can use compensating measures to overcome resource degradation problems (i.e. input substitution) such as the loss of topsoil, or the loss of nutrients by using other inputs (i.e. fertilisers) to maintain output. Thus, any definition that does not take into account input use necessary to maintain output misses part of the sustainability story.

Hence we investigate the use of a productivity measure known as Total Factor Productivity (TFP), defined as the change in the ratio of measured outputs to all inputs, as an indicator of sustainability. The rate of productivity growth is generally expressed as a rate of change between time periods. Regarding the assessment of sustainable development it is proposed that a constant or rising TFP - that is a value greater than or equal to one - indicates that the production system being considered is sustainable, providing service flows from natural resources are included as inputs.

Limitations and Further Research

This paper has a number of limitations that are to be taken into consideration in generalising the findings of this research. The research has a limited scope in that it examined the relevant issues of sustainability from the perspective of Australian agricultural sector. Therefore, future research can focus on the issues of sustainability in the context of other developed economies and a wide range of sectors such as chemical, paper and pulp, and dairy industries. Future research can also be extended to the developing and transitional economies where the issues of sustainability have different definitional and operational relevance. For example, a transitional economy such as China may have different view of sustainability in the context of their survival in a volatile world and tends to ignore some of the by-product of development (e.g. environmental pollution) for the sake of gaining economic growth. Research involving such economies may also uncover some facts about differing meaning and interpretation of sustainability from an operational point of view.

Acknowledgments

The authors would like to thank anonymous reviewers for their helpful comments on an earlier version of this paper.

References

- Byerlee, D. 1990. Technical Change, Productivity and Sustainability in Irrigated Cropping Systems of South Asia: Emerging Issues in the Post-Green Revolution Era. Economics Working Paper, International Maize and Wheat Improvement Centre, Mexico.
- Chisholm, A. H. and G.W. Edwards. 1990. "Population Growth, Agriculture and Land Degradation", in Clarke, H. R., A.H Chisholm, G.W. Edwards and J.O.S. Kennedy, Immigration, Population Growth and the Environment, Report to the Bureau of Immigration Research, AGPS, Canberra.
- Chisholm, A.H. and P. Hone. 1996. "Long Lived Resource Quality and Research Policy." In Conference Proceeding, Global Agricultural Science Policy for the Twenty-First Century: 227-262, Invited Papers, 26-28th August, Melbourne, Australia.
- Conway, G.R. 1987. "The Properties of Agroecosystem". *Agricultural Systems*, 24:95-117.
- DNRE (Department of Natural Resources and Environment). 1996. Annual Reports/National Parks Service.
- Ehui, S.K. and D.S.C. Spencer. 1992. "A General Approach for Evaluating the Economic Viability and Sustainability of Tropical Cropping Systems": 111-117, in *Issues in Agricultural Development: Sustainability and Cooperation*. Edited by M. Bellamy and B. Greenshields, I.A.A.E. Occasional Paper, 6.
- Hamblin, A. and G. Keyneur. 1993. Trends in Wheat Yields and Soil Fertility in Australia. Department of Primary Industries and Energy, Bureau of Resources Sciences, AGPS, Canberra.
- Harris, M and I. M. Fraser. 1997. Natural Resource Accounting and Ecological Indicators: A Review of Some Literature. Report prepared for the Department of Natural Resource and Environment, Melbourne, Victoria.
- Hone, P. 1994. The Impact of Productivity Growth on the Management of Land in the Australian Wool Industry. Unpublished PhD Thesis, School of Agriculture, La Trobe University.
- King, D. and P. Crosson. 1995. "Indicator of Natural Capital: Lessons Learned from the Upper Mississippi Natural Resource Accounting Project". In *Developing Indicators for Sustainability: The Nuts and Bolts*, Editor S. Batie, Proceeding of the Resource Policy Consortium, Washington D.C.
- Kirby, M.G. and M. J. Blyth. 1987. "Economic aspects of land degradation in Australia". *Australian Journal of Agricultural Economics*, 31(2):154-174.
- Lobry de Brun, L.A. 1997. "The Status of Soil Macrofauna as Indicators of Soil Health to Monitor the Sustainability of Australian Agricultural Soils". *Ecological Economics*, 23:167-178.
- Lockeretz, W.E. 1988. "Open Questions in Sustainable Agriculture". *American Journal of Alternative Agriculture*, 3(4):174-181.
- Lynam, J.K. and R.W. Herdt. 1989. "Sense and sustainability: sustainability as an objective in international agricultural research". *Journal of Agricultural Economic*, 3:381-398.
- Marten, G.G. 1988. "Productivity, Stability, Equitability and Autonomy as Properties for Agroecosystem Assessment". *Agricultural Systems*, 26:291-316.
- Mullen, J.D. 2002a. "Sustainable Resource Use May Impose Costs on Future as well as Present Generations". Contributed paper presented to the Australian Academy of Science's Fenner Conference on the Environment: 'Agriculture for the Australian Environment', 30 July – 1 August, 2002, Canberra.
- Mullen, J.D. 2002b. "Farm Management in the 21st Century". Invited paper presented at the 46th Annual Conference of the Australian Agricultural and Resource Economics Society. February, Canberra.
- Pearce, D. 1998. *Economics and environment: essays on ecological economics and sustainable development*. Edward Elgar, UK.
- Randall, A. 1987. *Resource Economics: An Economic Approach to Natural Resource and Environmental Policy*, 2nd Edition, John Wiley and Son.
- SCARM (Standing Committee on Agriculture and Resource Management). 1998. *Sustainable Agriculture: Assessing Australia's Recent Performance*. SCARM Technical Report 70.
- SOE (State of the Environment). 1996. *State of the Environment Australia*. Report presented to the Commonwealth Minister for the Environment, CSIRO Publishing, Collingwood, Victoria.
- Wills, I. 1997. *Economics and the Environment: A Signaling and Incentives Approach*. Allen and Unwin.

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