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**Sustainable Agriculture**

**by**

**Clem Tisdell**

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# SUSTAINABLE AGRICULTURE


## ABSTRACT

This paper provides an overview of concepts of sustainable agriculture and possible methods of attaining sustainability of agricultural yields and production. Reasons are given as to why modern industrialised agriculture might be less sustainable in terms of yields than traditional agriculture. The question of whether organic agriculture is likely to be more sustainable than non-organic agriculture is considered as well as organic agriculture's likely impact on wild biodiversity. The impact of the development of agriculture on wild biodiversity is assessed because some environmentalists see the conservation of wild biodiversity as an important ingredient of sustainable development. However, there is a policy conflict between conservationist groups. Some see intensive agriculture (including silviculture) as favourable to the conservation of wild biodiversity whereas others oppose such production methods as being unfavourable to wild biodiversity conservation. Reasons why modern industrialised agricultural systems are so widely adopted (and continue to be adopted) despite their apparent lack of sustainability are suggested. Market systems may tend to lock producers into unsustainable production methods.

# SUSTAINABLE AGRICULTURE

## 1. INTRODUCTION

Humans today are mostly dependent on agriculture for food, a necessity for their survival. This may explain why so much recent attention has been given to the question of whether agriculture, particularly modern agriculture, can maintain its current levels of production and those predicted for the near future. Furthermore, in the broader debate about conditions needed for sustainable development, there are concerns that the negative environmental spillovers arising from agriculture, especially modern or industrialised agriculture, will result in economic growth that cannot last (cf. Robertson and Swinton, 2005). Agricultural development also has changed and is altering the global pool of genetic resources in objectionable ways to many (e.g. loss of valued wildlife) and in a manner that may eventually undermine the sustainability of agricultural production itself.

Concerns about the ability of agriculture to provide sustainably for the needs of human populations are by no means new. For example, T. R. Malthus (1798) argued that because of the law of diminishing marginal productivity, that agriculture would be limited in its ability to feed an ever-increasing population. Later writers, such as David Ricardo (1817), argued that with technical or scientific progress and sufficient capital investment in agriculture that the Malthusian problem would not be a real issue. Engels (1959) dismissed the Malthusian view passionately saying, that 'nothing is impossible to science'. However, in recent times, doubts have arisen about whether intensive agriculture based on high inputs of capital and high use of resources external to farms, and relying on 'modern' science, is really sustainable. It is claimed that application of modern industrialised methods that have produced much agricultural growth are bringing about environmental changes (and in some instances, social changes) that will undermine that growth eventually and depress that level of agricultural production (Conway, 1998; Altieri, 2000, 2004).

There are many different views of what constitutes agricultural sustainability and about the necessary conditions to attain it. Therefore, in this chapter, a brief outline and discussion of contemporary concepts of agricultural sustainability follows and the concepts mainly used in this chapter are stated. The sustainability of modern (industrialised) agriculture compared to traditional agriculture is then examined and this is followed by a discussion of whether organic agriculture is likely to be more sustainable than non-organic agriculture. This leads

on to a discussion of the relationship between agricultural development and wild biodiversity conservation, examination of the broad issues raised in this essay, and conclusions.

## 2. CONCEPTS OF SUSTAINABLE AGRICULTURE

Consideration of concepts is important because they determine the focus of scientific enquiry. In relation to sustainable agriculture, we need to consider the following questions: What constitutes sustainable agriculture? Can it be achieved? If so, how can it be achieved? Is it desirable?

Several concepts of sustainable agriculture exist in the literature, most of which have been reviewed by Christen (1996). Christen (1996) claims, as a result of his review, that sustainable agriculture should have the following attributes: (1) ensure intergenerational equity; (2) preserve the resource base of agriculture and obviate adverse environmental externalities; (3) protect biological diversity; (4) guarantee the economic viability of agriculture, enhance job opportunities in farming and preserve local rural communities; (5) produce sufficient quality food for society; and (6) contribute to globally sustainable development.

Whether or not it is desirable for agriculture to possess all these attributes can certainly be debated. Few of these objectives may be absolutely desirable. For example, should rural communities be sustained at any cost? Furthermore, it may be impossible to fulfil all these desired objectives simultaneously. Consequently, some formulations of the desired sustainability attributes of agriculture may constitute little more than a pipe dream.

In this essay, the main focus will be on the maintenance or sustainability of agricultural product (or yields) as an indicator of sustainable agriculture and particular attention will be given to whether modern industrial-type agricultural systems are less sustainable than traditional agricultural systems.

At the outset, it should be recognised that sustainability of yields is only one valued attribute of the performance of agricultural systems. In comparing systems, many other attributes can also count such as the level of the yields or returns and the income distributional consequences of the farming system (cf. Conway, 1998, p.174). Furthermore, whether a

particular agricultural system continues to be adopted can be expected to depend not only on biophysical factors but also on its social consequences.

Even if differences in the sustainability of yields is the sole basis for choosing one agricultural system rather than another, anomalies can arise, as illustrated in Figure 1, and as discussed more generally by Tisdell (1999a) in relation to sustainable development. In Figure 1, the curves marked 1, 2, 3 and 4 show the performance of four alternative agricultural techniques over time for a finite relevant time-period. Only systems 1 and 2 exhibit sustainability of yields. However, system 4 is superior to both of these because it results in greater yields in every period. From some perspectives, it is even possible that system 3 is socially preferable to systems 1 or 2 (Tisdell, 1999a).

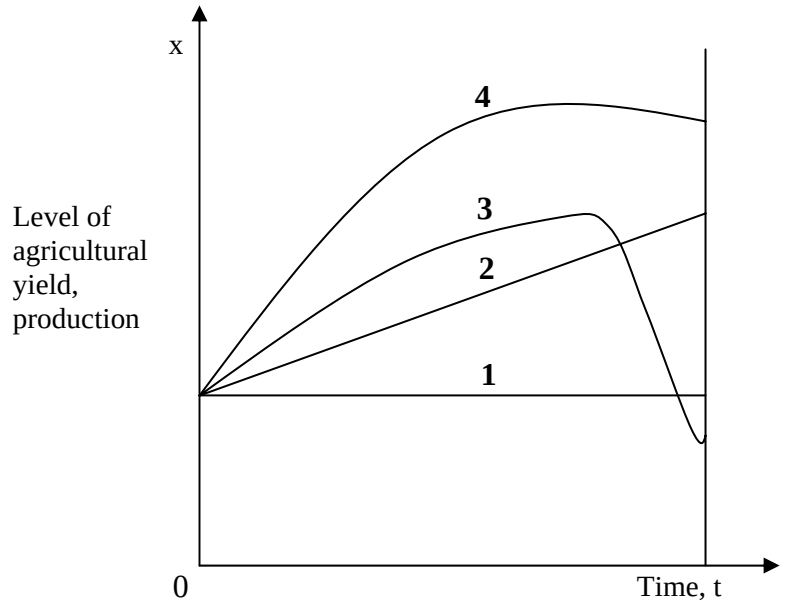


**Figure 1: Comparisons of some agricultural yield patterns – agricultural sustainability is not an absolute virtue**

Figure 1 makes it clear that sustainability of agricultural yields or production is not an absolute virtue. However, that does not mean that sustainability is unimportant. It can be a private and social folly to obtain considerable short-term benefit while ignoring or inadequately considering the long-term consequences of current actions. There is a danger that modern economies will do just that for reasons outlined in the literature about sustainable development that has evolved in recent times.

## 3. SUSTAINABILITY OF MODERN INDUSTRIALISED AGRICULTURE VERSUS TRADITIONAL AGRICULTURE

Conway (1985, 1987) and Altieri (1995) have argued that traditional agricultural systems are likely to be more sustainable than modern industrialised agricultural systems. However, both modern and 'traditional' systems can be diverse and agricultural systems are still evolving. Therefore, while the above observation seems to hold broadly, it needs some qualification as, for example, pointed out by Pretty (1998). For instance, although slash-and-burn or shifting agriculture (and early forms of agriculture) can be relatively sustainable when rotation cycles are sufficiently shortened, yields decline and it no longer remains sustainable (Ramakrishnan, 1992).

Methods for undertaking modern agriculture can vary. Technologies are available that can increase the sustainability of yields in modern agriculture compared to widely used methods. These include intercropping, appropriate crop rotations, agroforestry, sylvo-pastures, green manuring, conservation tillage (low or no tillage), biological control of pests rather than by the use of pesticides, and integrated pest management (Conway, 1998, p.170; Conway and Barbier, 1990). These technologies, however, are not dominant in modern agriculture and do not replicate traditional agroecosystems.

Altieri (2004, p.35) estimates that 10-15% of all land under cultivation in the developing world is still cultivated using traditional cultivation methods. These are a result of a complex co-evolutionary process between natural and social systems. They are usually place-specific and well adapted to local conditions. Altieri's estimates also indicate that a very low percentage of cultivated land globally is cultivated using traditional methods.

On the whole, most modern industrialised agricultural systems differ significantly from those adopted in traditional agriculture. Traditional agroecosystems are, as a rule, characterised by several features that help maintain yields. These include high species numbers (considerable biodiversity); use of local varieties of crops of wild plants and animals well adapted to local conditions; maintenance of closed cycles of materials and little waste because of effective recycling practices; pest control through natural levels of external inputs; pest control through natural biological interdependencies; high structural diversity in space (intercropping) and in time (crop rotations) and a high degree of adaptation to local microenvironments (cf. Altieri,

2004; Gliessman, 1998). They tend also to be labour-intensive and have evolved as a result of local knowledge.

Modern industrialised agrosystems usually lack most of the attributes associated by Altieri (2004) and others with traditional agrosystems. They are characterised by use of few species on the farm (often only one farmed species); use of varieties of crops not developed locally to suit local conditions (for example, varieties developed by companies, often multinational ones, specialising in plant breeding), the presence of monoculture, and relatively open cycles resulting in considerable imports of materials to farms as well as substantial exports of materials from them in the form of products and wastes.

The openness of most modern industrialised agricultural systems compared to the relatively closed cycles of most traditional agricultural systems creates sustainability problems for modern agriculture. Potential obstacles to sustaining yields from modern agriculture include the following:

1. Possible lack of future availability of many external inputs, such as fossil fuels and some types of fertilizer, because global stocks are finite and they are exhaustible and non-renewable (Ewel, 1999);

2. Reduced soil fertility due to long-term use of chemical fertilisers, e.g. increased acidity of the soil, and impoverishment of soil structure due to frequent cultivation and lack of return of organic matter to the soil to provide humus (Ewel et al., 1991). Frequent cultivation and lack of intercropping may also encourage soil erosion eventually reducing soil depth so much that yields fall;

3. The widespread use of chemical pesticides and herbicides in modern agriculture can create sustainability problems. For example, resistance of pests to pesticides tends to develop in the long term. Furthermore, some pesticides and weedicides have adverse impacts on soil flora and fauna which can negatively impact on farm productivity;

4. Given the urbanised structure of modern societies (and the fact that the degree of urbanisation is continuing to rise, especially in developing countries) large amounts of produce sent by farms to urban areas deplete or ‘mine’ soils on farms. Little of the

wastes from off-farm consumption is recycled to farms, mainly because of the high transport and collection costs involved in their return to agricultural land. This large exported surplus of modern agriculture entices agriculture into the high use of artificial external inputs. Therefore, growing urbanisation may create a major barrier to the development of sustainable agriculture in modern times and makes it difficult, if not impossible, to return to traditional agroecosystems; and

5. Modern agriculture is often a source of unfavourable environmental externalities or spillovers. This is because of its open-cycle character and the type of cultivation and husbandry practices adopted. It can pollute shared water bodies, cause salting or water logging of soils over extensive areas and seriously disrupt hydrological cycles. Furthermore, the uncoordinated use of shared water bodies by agriculturalists can threaten the maintenance of their production. This can happen, for instance, if farmers initially use water from underground aquifers at a rate faster than their rate of recharge.

Modern agriculture is associated with a global reduction in crop varieties and breeds of livestock. This is a result of: (1) growing globalisation (the extension of free market systems geographically and easier access to knowledge globally); and (2) the development of food production technologies and methods that allow increased artificial manipulation of micro-environments in primary food production; and (3) more widespread trade that reduces dependence of local agriculture on local material inputs (Tisdell, 2003). Market extension encourages greater specialisation in agricultural production by farmers and the adoption of specialised breeds of livestock or varieties of crops and results in path dependence, as pointed out by Tisdell (2003). Consequently, agricultural production systems become more specialised. This reduces the scope for their co-evolution at the local rural level and agricultural innovations have primarily become dependent on large specialist corporations supplying inputs to farms and/or marketing farm produce (Heffernan, 2000).

The change in the organisational structure of agriculture involving greater dependence on external inputs supplied by large corporations tends to reinforce the dependence pattern. Sellers of agricultural inputs focus their efforts and research on ways to sell greater external inputs to agriculturalists. Scientific research on non-traded inputs and products is liable to be neglected. Local knowledge of farmers may be lost and local development of agroecological

systems may cease or be curtailed. These factors, as well as advertisements and other means of marketing, may bias the agricultural development path in favour of open-cycles. In addition, urban 'bias' (Lipton, 1977) in agricultural production to serve urban areas grows as urbanisation gains momentum. Government policies may encourage agricultural production for sale to urban areas (or even international export) rather than for subsistence (cf. Kiriti and Tisdell, 2003).

Table 1 summarises those attributes of modern agriculture that are liable to make it less sustainable than traditional agriculture. It is based on the representative typology adopted, for example, by Altieri (2004). It raises the question of why has there been such a swing to modern industrialised agriculture even though it lacks many sustainability properties.

However, before discussing this, let us briefly consider the sustainability of organic agriculture compared to non-organic agriculture.

**Table 1:**
**Typical attributes of modern industrialised agriculture**
**and of traditional subsistence agriculture**

| Modern Agriculture | Traditional Agriculture |
|---|---|
| 1. High level of external inputs. Low level of self-sufficiency | 1. Low level or no external inputs. High degree of self-sufficiency |
| 2. Open-cycle agrosystems. Encouraged by market extension and urbanisation | 2. Closed cycle agro-systems. No or little marketing |
| 3. Loss of agricultural biodiversity. Loss of co-evolution | 3. Retention of agricultural biodiversity. Evolution of genetic material by co-evolution |
| 4. High degree of export of wastes resulting in adverse externalities – pollution. | 4. Low degree of export of wastes. Low external impacts |
| 5. Significant reduction in on-farm natural resources due to export of products and 'wastes' | 5. Little reduction in on-farm natural resources |
| 6. Dominance of monocultures and specialised forms of agricultural production | 6. Mixed systems of agriculture production e.g. polyculture. |
| 7. Market-dominated. Increasingly dominated by global markets | 7. Subsistence or semi-subsistence use dominates |

## 4. THE SUSTAINABILITY OF ORGANIC VERSUS NON-ORGANIC AGRICULTURE

The demand for organic agricultural produce has increased in more developed countries (Lampkin and Padel, 1994). Reasons for this include the following:

(1) Organic produce is widely believed to be healthier than food produced by non-organic agricultural systems;

(2) A high degree of sustainability is attributed to organic agriculture compared with agroecosystems that extensively use chemicals, such as pesticides and artificial fertilisers; and

(3) Organic agriculture is believed to be more environmentally friendly than modern agriculture, including less threatening to wildlife.

However, varied organic agroecosystems are possible and not all replicate traditional farming systems. For example, organic agriculture can depend on fossil fuels for energy and on high import of organic material to farms. There may be a high degree of specialisation in farm production and significant agricultural biodiversity loss. The use of some organic materials can pose health risks unless appropriate care is taken; for example, the use of human excreta as fertiliser. Wildlife may be threatened by habitat change, although the degree of change may be less than with industrialised modern agriculture.

Some forms of organic agriculture, for example, cattle and sheep grazing in parts of Australia involve extensive land use. Nevertheless, such land-uses have been implicated in loss of wild species and significant habitat changes (Tisdell, 2002, p.91).

While organic farming is likely to be more favourable to the conservation of wildlife than non-organic farming (for example, because it does not use chemical pesticides), that does not mean that organic farming is favourable to biodiversity in the wild. Organic agriculture usually involves major changes in natural habitat or, in the terminology of Swanson (1994, 1995), much land conversion. This is an important factor in reducing biodiversity in the wild.

Furthermore, not all organic farmers are favourably disposed towards wildlife (McNeely and Scherr, 2003, p.91).

## 5. AGRICULTURE AND THE CONSERVATION OF WILD BIODIVERSITY

Many conservationists favour protection of wild biodiversity as an ingredient of sustainability. Unfortunately, the development of agriculture, particularly modern agriculture, has reduced this biodiversity and threatens to reduce it even further (McNeely and Scherr, 2003, Ch.4; Pretty, 1998, pp.62-65; Tisdell, 1997).

The mechanisms by which agricultural expansion (especially of modern agriculture) does this are varied and complex. They include:

(1) Land clearing and conversion which results in loss of habitat for many wild species (cf. Swanson, 1994, 1995);
(2) Greater uniformity of habitat with loss of diversity in niches and loss of niches for wild species (Tisdell, 1999c, Ch.4);

(3) Increased competition of agriculturalists with wild species for natural resources resulting in less availability of these resources to wild animals and/or the destruction of wild species by agriculturalists as pests;

(4) Poisoning of wildlife as a side-effect of agricultural pesticide use;

(5) The release of pollutants from farms that poison wildlife or alter their natural environments in an unfavourable way. For example, eutrophication of water bodies as a result of farm run-off of nutrients can lead to the demise of some wild species; and

(6) Hydrological changes brought about by modern farming can seriously affect wild biodiversity. For example, farm irrigation schemes can greatly reduce the level of flows and cyclical patterns of river flows and this can adversely affect species dependent on the previously natural rhythms, for example their breeding, and lead to loss of seasonal wetlands, and even permanent wetlands. Regeneration of the red river gum on the Murray River basin in Australia, for instance, is threatened by the fact that this river is heavily utilised for human use (mostly agricultural) and the variability of

its flows have been much reduced. Red river gums are important for the survival of several Australian wildlife species. In addition, the breeding of several species of wild duck is hampered by reduced frequency of flooding. Or to give another example, removal of trees with the aim of increasing agricultural productivity (an aim not always realised in this case) often leads to the death of other trees and vegetation in areas subject to dryland salinity. Furthermore, streams and other water bodies in the area may become very saline. This can result in loss of native species as has occurred in parts of Western Australia.

Because agriculture (broadly define) accounts for the use of such a large area of land globally (McNelly and Scherr, 2003, p.32; Tisdell, 2004) and, politically at least, large increases in protected areas are unlikely, maintenance of wild biodiversity is highly dependent on conservation of wildlife outside protected areas. With this in mind, McNeely and Scherr (2003, Ch.5) have advocated the development of ecoagriculture, this is the development of agriculture that is more favourable than currently to the protection of wild biodiversity and natural ecosystems. They outline policies that might be adopted to promote ecoagriculture. However, some of these policies may require more in-depth consideration. For example, they recommend increasing farm productivity as a means to reduce land conversion to agriculture and give a favourable impression of Green Revolution technology saying that it “almost certainly helped to slow land conversion in the developing world” (McNeely and Scherr, 2003, p.136). However, while it certainly helped to provide more food for people, it is by no means clear that it had positive consequences for wild biodiversity conservation.

In fact, a difference in views appears to exist among conservationists about which forms of agriculture are most favourable to nature conservation. Some conservationists favour intensive agriculture and silviculture on the basis that this is highly productive compared to extensive to agriculture or silviculture (FAO, 2003), whereas others favour the opposite policy.

Those favouring intensive agriculture or silviculture believe that although major habitat change would occur in the farmed or plantation area, this will enable a larger land area to remain in a natural state than if extensive agriculture and silviculture is practiced and that this will conserve more biodiversity in the wild than otherwise. However, the situation appears to

be quite complex and needs more intensive evaluation before coming to a firm policy conclusion.

## 6. DISCUSSION

If the productivity of modern industrialised agriculture is unsustainable, why have such agroecosystems been so widely adopted and why do they continue to be adopted given private and social misgivings about them? Let us consider such a choice from the viewpoint of an individual agriculturalist and from a social perspective.

Agriculturalists may adopt modern industrialised agroecosystems for the following reasons:

(1) They may be unaware of the degree to which these systems lack sustainability. Sellers of external agricultural inputs that contribute to this lack of sustainability have no incentive to inform potential buyers about this aspect;

(2) High levels of present returns available in the short- to medium-term from modern agriculture may be attractive to farmers. They may, for example, discount their future returns at a high rate. The aim of many is to obtain funds to educate their children so they can earn higher incomes by leaving agriculture. Furthermore, if a higher return on funds can be obtained from investment of the capital tied up in an agricultural property by investing it elsewhere in the economy, there is an economic incentive to realise the capital (for example, by mining farm resources) and invest the capital elsewhere. (Clark, 1976);

(3) Modern economies are cash-based economies. Farmers need to obtain cash to educate their children, obtain health services, obtain other non-agricultural commodities and pay government taxes. To do this, farmers must market produce. When market transaction costs and other factors are taken into account, the costs of using traditional methods of production to supply agricultural produce to markets may exceed that from the use of modern agricultural techniques. Market competition may make it uneconomical for farmers to use traditional techniques, even if modern techniques result in higher costs in the long-term (Tisdell, 1999b, p.48-53). The market itself becomes a barrier to the retention of traditional agricultural technologies;

(4) Government policies appear to encourage the development of commercial agriculture via the nature of their extension services, information provision, the direction of agricultural research and, in some cases, subsidies for external inputs. This may partly reflect urban bias (Lipton, 1977) since urban populations depend on the agricultural surplus supplied by commercial agriculture;

(5) In some societies, power relationships and entitlements in families may bias agricultural development in favour of commercial crops produced from modern agroecosystems. For instance, in some parts of Africa, husbands have control of cash earned from cash crops and control of crops by women is mostly restricted to subsistence crops (Kiriti and Tisdell, 2003, 2004); and

(6) Environmental spillovers from modern farming practices will be ignored by farmers in their private decisions unless their costs or benefits are internalised. Farm costs still do not reflect many of these externalities.

A second pertinent question is why do modern agrosystems have so much social support if they are unsustainable. Reasons may include the following: current generations may not be as much concerned about the fate of future generation as is sometimes imagined; their practical concern may extend to only two or three future generations. Or again, it may be widely believed that scientific advances will be able to address any agricultural sustainability problems that may arise in the future. Furthermore, special interest groups and governments may be myopic in their outlook.

The increasing dominance of economic liberalism based on market operations is likely to reinforce the dominant position of modern industrialised agriculture. Increasingly governments have vacated the area of agricultural R&D in favour of private corporations and have passed property rights legislation covering new plant varieties and transgenic material These provide incentives to private industry to develop and market new genetic material. This is likely to increase the dependence of agriculture on external inputs and may further reduce agricultural biodiversity (Altieri, 1999). In a market system, suppliers of agricultural materials are interested in promoting open agricultural systems rather than closed ones. This is because the more closed an agricultural system, the fewer are the sales of agricultural suppliers.

## 7. CONCLUDING OBSERVATIONS

Modern industrialised agricultural systems have produced considerable farm surpluses and have enabled large urban populations to be sustained at relatively high standards of living. Doubts, however, have arisen about how well these modern systems can sustain their productivity in the long run given their high level of dependence on external inputs, their open-cycles, their degradation of their natural resource-base and their erosion of genetic assets. Nevertheless, there seems little prospect of a return to traditional agroecosystems in the near future. It is difficult to see how they would be able to support the degree of global urbanisation that currently exists and which is growing, especially in developing countries.

At the same time, there is a case for greater government intervention in modern agriculture to increase its sustainability. For instance, there is a case for public policies, such as taxes on unfavourable agricultural externalities or subsidies on favourable externalities, they ensure that externalities are taken into account by farmers (cf. Robertson and Swinton, 2005). However, lack of agricultural sustainability does not arise solely from lack of consideration of environmental spillovers, as should be clear from the above discussion.

Market systems can encourage the use of unsustainable productive practices. Policy-makers should, therefore, be more guarded in their support for market extension, particularly in developing areas where subsistence and semi-subsistence agriculture still prevails. Increased government support for agroecological research (Dalgaard et al., 2003; Pretty, 2003) may also be justified. This is because its benefits are mostly internal to farms and property rights in its research results are difficult or impossible to establish and enforce. In a market system, researchers have little economic incentive to engage in such research because they can appropriate few gains by marketing commodities based on results from it.

The market system, the driving force of modern agriculture, appears to be a two-edged word. On the one hand, market extension promotes the division of labour and specialisation in agricultural production (as well as other types of production) and as Adam Smith (1910) pointed out, these are forces for raising productivity in any economy. But, on the other hand, will this increase in agricultural productivity be sustained? Market extension brings into play forces (identified in this chapter) that at the very least make it difficult to sustain the productivity of market-based agriculture. This needs to be more widely recognised than at present. In addition, the view expressed by White et al. (1993, p.236) that “on balance,

markets probably promote sustainability more than they hurt [it]" is not proven. Furthermore, even if this statement by White et al. is false, current societies do not appear to be in a mood, nor in a position, to alter radically their market systems in the foreseeable future. We may now be locked into market systems.

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