SUSTAINABLE AND CONVENTIONAL AGRICULTURE: AN ECONOMIC ANALYSIS OF AUSTRALIAN CEREAL-LIVESTOCK FARMING

Els Wynen

B.Sc. (Agric.) Deventer, The Netherlands
M.Sc. (Agric. Econ.) Reading, U.K.

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School of Economics

La Trobe University
Bundoora, Victoria, 3083
Australia

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SUMMARY

A review of the problems of conventional agriculture (such as pest resistance to pesticides, and deterioration of human health and of soil and water quality) is carried out. The extent to which these problems can be alleviated by switching to sustainable agriculture is examined. The main emphasis of the thesis is on the effects of sustainable agriculture on farmers' returns, with some consideration of net benefits to the community at large.

The effect on the farmers' returns are examined in two ways. First, a literature review is undertaken of studies in which private net benefits accruing to sustainable farmers are compared with those accruing to conventional farmers. Second, a detailed comparative survey of Australian sustainable cereal/livestock farmers and their conventional farmer neighbours is carried out for 1985-1986. Financial and non-financial aspects are analysed. The effects of transition on the level and variability of wheat yields in the long run are examined.

Private returns to farming are influenced by existing marketing arrangements. The cost to sustainable farmers of Australian wheat marketing regulations are found to offer no incentive to exploit the higher prices for organically grown wheat.

Government policies influence the relative profitability of alternative farming systems. A linear programming model is used to determine how the optimal farm system is affected by changes in fertiliser and pesticide taxes and subsidies, and changes in commodity prices. Considerable changes in input and output prices are found to be needed before changes in input use take place.

Policy implications of the findings in the earlier chapters are explored. Arguments are presented for government involvement in the areas of non-subsidisation or taxation of synthetic fertilisers and pesticides, subsidies for research and extension in sustainable agriculture, and the implementation of quality control measures.

STATEMENT OF AUTHORSHIP

Except where reference is made in the text of this thesis, this thesis contains no material published elsewhere or extracted in whole or part from a thesis presented by me for another degree or diploma.

No other person's work has been used without due acknowledgment in the main text of the thesis.
This thesis has not been submitted for the award of any other degree or diploma in any other tertiary institution.

Els Wynen
July 5, 1989

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1 INTRODUCTION

Until the middle of last century, a successful agricultural management system was largely dependent upon the maintenance of an ecological balance on the farm. This was achieved through employing management techniques including certain crop rotations, mechanical cultivation, and the use of livestock. Such management methods enabled agriculture to be sustained for many centuries.

In more recent times scientific advances have allowed increased productivity per unit of land and of labour by the use of synthetic fertilisers and pesticides[1]. This new technology was widely adopted by farmers in the western world, and is referred to here as conventional agriculture.

Although the productivity of land has increased in the short term, concern exists that modern agriculture may not be sustainable in the long term. Central to this concern are such phenomena as pest resistance to pesticides (see, for example, Debach 1974) and soil degradation through erosion, acidity, salinity and compaction (see, for example, Department of Environment, Housing and Community Development (1978); Hodges and Arden-Clarke (1986)). These unwanted effects are experienced partly on-farm and partly off-farm as external diseconomies. Other undesirable effects of conventional farming include those on human health. Deterioration of water quality is in the form of effect on human health and on the environment. Problems of conventional agriculture are discussed in more detail in Chapter 2.

In Australia, as in many western countries, a few farmers never adopted the conventional technology. Others adopted it, but subsequently returned to farming without synthetic fertilisers and pesticides. In the past it was generally believed that this form of agriculture, here called sustainable agriculture, could not be considered a viable alternative to conventional farming. More recently, however, interest in sustainable farming has increased. This is probably due partly to early work by people such as Klepper et al. (1977), which indicated that returns from

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[1] The word 'pesticides' is used as an umbrella word referring to all agricultural biocides such as insecticides, herbicides, fungicides and nematocides.

sustainable farming could be comparable to those on conventional farms, and partly to increased awareness of problems with conventional agriculture. This last consideration was translated into a strong growth in demand for products from sustainable agriculture over the last decade.

The objective of this thesis is to compare sustainable and conventional farming in Australia's main agricultural sector: cereal/livestock. A detailed survey was undertaken to analyse not only the financial returns to farming, but to also consider the differences in input use and practices, and output quantities and prices. The effects of institutional factors which influence the financial results, such as marketing arrangements and taxes and subsidies on input and output prices, are examined. In addition, non-financial aspects relevant to sustainable farmers are discussed.

Sustainable agriculture is defined and discussed in some detail in Chapter 3. Differences in use of inputs and in outputs between sustainable and conventional farming are considered. Comparisons of sustainable and conventional agriculture, mainly carried out overseas, are analysed.

Chapters 2 and 3 are summarised in Chapter 4, where the social benefits and costs of a partial movement from conventional to sustainable agriculture are described.

The survey conducted of sustainable cereal/livestock growers and their conventional farmer counterparts in South-eastern Australia is reported upon in Chapter 5. Data for one cropping year, 1985-86, are analysed.

It is often argued that the transition from conventional to sustainable farming affects the yielding capacity. In addition, questions are raised about the long-term yields on sustainable farms. Wheat yields of interviewed farmers for whom time-series data are available are examined in Chapter 6.

Financial returns to farming are influenced by prices received for the produce. Although consumers are willing to pay premium prices for many products grown on sustainable farms, marketing arrangements for some Australian produce (including wheat) are such that it is difficult for producers to capture the premiums. Wheat marketing arrangements are considered in Chapter 7.

Distortions in the wheat market might not be the only source of differential treatment between sustainable and conventional farmers in Australia. For example, taxes or subsidies on inputs used differently in the two management systems will give different signals to the two classes of growers. The effect of government intervention in the fertiliser and pesticide market and of the market forces in wheat and livestock marketing on the private financial benefits and the externalities caused by the inputs is estimated in Chapter 8 (for a definition of externality: see p48).

In Chapter 9 policy implications are discussed of the findings of this study. In Chapter 10 a short summary is provided and topics for further research suggested.

2 CONVENTIONAL AGRICULTURE: SOME PROBLEMS[2]

2.1 Introduction

The technology incorporating the use of synthetic fertilisers and pesticides has contributed considerably to productivity increases in agriculture over the last century. However, it is increasingly recognised that severe problems are associated with the use of this technology. This has lead to the emergence of an alternative form of agriculture: 'sustainable agriculture'.

Private costs and benefits of sustainable as compared to conventional farming have been assessed by some, and are reviewed in Chapter 3. Some private costs, though, are not captured in these comparisons, mainly because they are difficult to measure. They include pest resistance to pesticides, negative effect on human health, and degradation of soil and water quality. They are also the main components of the externalities related to conventional farming.

Literature is available about the physical aspects of these problems with pests, human health, soil and water. It is more difficult to find literature on the costs and benefits in financial terms. Pimentel et al. (1980) estimated the total 'indirect' private and external costs (excluding the input price) of the use of synthetic pesticides in the USA at US$839m annually. This compares with a total annual expenditure of US$2200m on pesticide treatments including materials and application (Pimentel et al. 1978). An estimate of the external cost of the use of pesticides in The Netherlands amounted to Fl.300m - Fl.550m, with total expenditure on chemicals of Fl.700m per year[3] (Van der Vaart 1987). All figures, however, should be treated with care since estimation of these costs is in an early stage. Refinements in techniques and assumptions could affect the values.

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[2] An earlier version of most of this chapter was published in Wynen and Fritz (1987). Wynen is the sole author of this material.

[3] A$1 = Fl. 1.681: 23 June 1989.

In the rest of this chapter the effects of conventional farming on the physical aspects of pest resistance to pesticides, human health, and soil and water quality are discussed in more detail, although no comprehensive review is attempted. Literature from both overseas countries and Australia is considered. No attempt is made to quantify the costs.

2.2 Pests, Pesticides and Pesticide Resistance

One of the characteristics of currently available synthetic pesticides is their ability to affect a broad spectrum of life. This means that, apart from their toxicity for a particular target, other organisms can be, and frequently are, affected. For example, insecticides usually are damaging not only to a pest, but also to its (insect) predators. The effect of insecticides on predators can be more devastating than on the pest for several reasons. One reason is that predators usually are fewer in number, and slower breeding than their prey. Collins (1985-86) mentions other reasons. These include the disappearance of host and consequent starvation of predators after the use of a pesticide; and persistence and increased concentration of a pesticide in the food chain, which would expose the predator to a higher level of pesticide than the pest. The result is that once a pest develops resistance to an insecticide, the previous existing safety mechanism, such as predators, might no longer be available, and the pest could become an even greater problem than before the initial use of the pesticide.

Another consequence of this process can be that insects, not previously considered pests, do become so, once they develop a resistance to pesticides, and their predators have decreased in population. Debach (1974, p.12) remarks that '...in almost all intensively treated crops today, chemical applications are being made against upset pests (i.e. ones that formerly were innocuous) nearly as frequently as against the few key pests actually lacking established effective natural enemies'. He continues that '...in intensively treated crops it is no longer possible to distinguish between real pests...and man-made upset pests...'. Debach (1974) presents numerous references on the topics of adverse effects of pesticides on insect and mite pests, their natural enemies, and the basic biological and ecological aspects involved.

The first reports of resistance to synthetic pesticides appeared around 1947, only a few years after they were first used on a large scale (Briejer 1968, p.102). Since that time resistance has become an increasing problem (Carson 1962; Briejer 1968; Debach 1974). In The Netherlands a mite, *Tetranychus urticae* Koch, developed resistance to four generally used pesticides within a period of one to four years after the introduction of these materials for general use (Oppenoorth 1969, p.46). Indeed, Debach (1974, p.2) maintains that the use of certain pesticides is a recipe for an eventual increase in pests.

In connection with agricultural pests and diseases, Carson (1962, p.236) reports 65 crop-destroying pests resistant to pesticides in 1960. Resistance to agricultural and veterinary pesticides on a global level was surveyed by the FAO Working Party on Resistance in 1973. It yielded 300 replies, 20 per cent of which were new cases of resistance registered since an earlier survey in 1965 (Busvine 1976, p.199). This development was partly attributed to an excessive dependence on pesticides '...at the expense of other control measures such as crop rotation, the use of immune varieties, and changes in agricultural practices.'

Resistance problems have occurred most often with insects, while weeds and fungi have been less affected. In the case of weeds this is due partly to the fact that a different kind of weed can take over when one particular weed has been reduced. Another reason is the relative ease of application of herbicides (due to the immobility of plants), decreasing the chance of the use of sublethal doses and therefore the chance of resistance. Other reasons include: a limited number of generations per year; a relatively short period of extensive use of herbicides as compared to insecticides; and the use of other means of combatting weeds such as crop rotation, fallowing, and the use of alternative herbicides (Busvine 1976, p.201).

The relatively late occurrence of fungicide resistance as compared to insecticide resistance is due to the fact that synthetic fungicides were not widely used before 1970. However, since that time, resistance to fungicides has developed rapidly (Busvine 1976, p.201).

Adverse environmental conditions, associated with the use of fertilisers and pesticides, have been shown to cause increased susceptibility of crops to pests. This is discussed by White (1984). He maintains that relatively high levels of soluble nitrogen concentrate in certain parts of the plants under stress conditions, enabling young offspring from pests to survive at an unusually high rate. White (1984) shows that literature about the effect of stress factors such as infection by disease organisms, temperature, solar radiation and irradiation, nutrient deficiencies or excesses, and the use of pesticides (insecticides, fungicides or herbicides) supports the theory that pest infestations are relatively high in crops under stress.

The consequences of extensive use of pesticides can be subtle or dramatic. One of the most dramatic is the disappearance of an agricultural industry altogether. For example, Adkisson (1971) notes the virtual disappearance of the cotton industry from the Lower Rio Grande Valley of Texas and northeastern Mexico. This was mainly due to the increase of two pests, which were formerly of secondary importance.

In Australia a general picture of resistance of crop pests to insecticides, fungicides and herbicides has been given by Powles (1985), and of animal pests by Arundel (1985). Individual reports about this phenomenon have also been published. Cattle ticks (especially in Queensland), and sheep blowflies were amongst the first immune pests recorded (Busvine 1976, p.199).

Malathion resistance in grain storage insects was recorded in Western Australia in 1978 (Rimes and Moulden 1978), and also in Queensland (Collins 1984). Collins (1984) reported that the sawtoothed grain beetle, apart from being resistant to malathion, also shows resistance to fenitrothion and '...in some instances these insects showed resistance to all the commercially available protectants'.

Lovett (1982, p.21) has reviewed reports on pest resistance in Australia. Lovett mentions that in one of these, *Heliothis armigera*, an insect which in Queensland is a pest on a wide range of crops such as tobacco, maize, sorghum, cotton, sunflower, linseed, peanut, tomato, French bean, cucurbits and pomme fruit, has been reported as resistant to a number of pesticides in the Ord River area in Western Australia. In another report resistance of the *Heliothis* spp. to synthetic pyrethroids was discussed. In 1983 resistance to the same insecticide was detected in *Heliothis* *armigera* in Queensland and, to a lesser extent, in Northern New South Wales (Prentice 1983).

In April 1983 the Stock Journal reported the resistance of the spotted alfalfa aphids to several pesticides. In 1982 the first cases of resistance of weeds to herbicide were reported in Australia (Jennings 1984a). Both rye grass and barley grass were mentioned in this connection.

Resistance of sheep pests such as blowflies, worms and lice to different kinds of pesticides is reported upon in Australian rural newspapers regularly (see, for example, Murray (1988) and Larsen (1988)).

In summary, the adverse effects of the use of pesticides can be considerable, both for present and future productivity. One reason for this is the development of resistance to pesticides by primary pests, and also to the increase of importance of secondary pests. Although these phenomena have not yet happened on a large scale in Australia, the first signs of this trend have appeared.

2.3 Human Health

2.3.1 Introduction

Human health can be affected in many ways by the use of fertilisers and pesticides. The main problems occur during the processes of manufacturing, transportation, storage, and use in agricultural production of these substances. Food quality (including residues on food) is another major area of potential problems. Coye (1986) provides a detailed picture of the factors contributing to the '...health externalities created by agricultural systems' (p.166) on agricultural workers and the community as a whole.

During the manufacture of pesticides problems can occur in many ways. Large scale accidents have happened from time to time (for example in Soveso (1976) and Bhopal (1984)), with thousands of people dead and many more affected. In a Californian pesticide factory a high degree of infertility has been reported amongst male workers (Whorton, Krauss, Marshall and Milby 1977).

Fires in chemical warehouses in Australia have drawn attention to problems with storage of pesticides. For example, in Zillmere, Queensland (Murphy 1985) such fires resulted in health problems (such as tiredness, headaches, sore throats and eyes) to a number of people in the neighbourhood. Also in Melbourne fires in chemical storage places have caused concerns for human health (Warneke 1986).

However, the issues in this section focus on the agricultural production process and food quality. Fertilisers, the main groups of pesticides (consisting of carbamates, organo-phosphates and organo-chlorines), and food additives are discussed. The effects of pesticides on people are examined in terms of the short-term, or acute toxicity, and of the long-term, or delayed, effects. Deterioration in water quality, although of importance partly because of its effect on human health, is discussed in Section 2.5.

2.3.2 Fertilisers

Literature about the effects of fertilisers on human health has been reviewed by Hodges and Scofield (1983a), who consider that nitrogenous fertilisers cause the most dramatic problems. The problems usually derive from the change of nitrate into nitrites, occurring both in people and in livestock, affecting their health.

The main source of NO_3 (nitrate) was regarded to be pollution of water supplies, through percolation through the soil. Another effect of nitrogen on human health is through the accumulation of NO_3 in food plants. The particular research quoted concerned methaemoglobinaemia (the 'blue baby syndrome') in babies consuming spinach, an extensively used component of baby food. Water pollution and accumulation of NO_3 in plants is more likely to happen in situations of monocultures and inorganic N applications (as is the case with synthetic fertiliser) than when organic sources of N are applied and where the ground is kept covered (which is more probable under sustainable agriculture).

2.3.3 Pesticides: short-term effects

The effects of pesticides on human beings has been the subject of much literature.

Carbamates and organo-phosphates are extremely toxic, but their toxicity can deteriorate relatively fast (a half-life of a few weeks would not be exceptional). Organo-chlorines have a comparatively low toxicity, but are persistent in the environment for a long period (a half-life of up to 30 years). The time needed for the breakdown of the compound depends on several factors, such as soil type and meteorological circumstances. Also the susceptibility of people exposed can differ, depending on such factors as age, sex and nutritional condition.

Both carbamates and organo-phosphates, and some organo-chlorines, act on the nervous system, inhibiting the working of the enzyme cholinesterase. This enzyme is needed to counteract the workings of another enzyme, acetylcholine, which enables the 'translation' of signals of the brain into the movement of a muscle. Inhibition of cholinesterase causes muscle movement to be out of control. The first muscles to be affected are usually those of the larger bronchi and of the gastrointestinal tract. It is for this reason that the symptoms of poisoning include tightness of the chest, abdominal pain, nausea and vomiting (Traynor 1970, p.23). Other symptoms include depression, paranoia, and recurrent nightmares (Krosney 1982).

Many casualties related to short-term effects are due to accidents or careless handling of the compounds. In a survey conducted in North-Carolina in 1969-70 on 245 randomly selected farms, 68 per cent of the farmers indicated that they had never used safety clothing during application. Used containers were discarded in the woods or left in the fields by 70 per cent of the farmers (Gehlbach, Williams, Woodall and Freeman 1974). In the same study mention was made of the multiplicity of the available pesticides, and the associated problems with treatment in case of poisoning due to difficulties with identification of the material.

In a study on herbicide use Conacher and Conacher (1986, pp.105-11) report on many examples and surveys, in which incompetence in, or ignorance of, the appropriate handling of pesticides is a problem in the use of these substances. Although regulations are usually in force, and correct handling of the pesticides is explained on labels on containers, this does not guarantee the reading of those labels or compliance with the directions.

Estimates of poisonings are likely to be underestimates. Some symptoms of acute poisoning are non-specific (for example symptoms like those of influenza) and might be difficult to recognise. In addition social, psychological, economic and legal factors can be important, leading to non-adherence to accident-preventing legislation. Examples of reasons for not reporting illnesses are: fear of deportation in the case of illegal workers; lack of awareness of workers' compensation; and fear of missing work during peak seasonal income periods (Kahn and Widess 1984).

Strigini (1982) published data for acute, pesticide-related illnesses reported in California from 1973 to 1977. This State is considered to have the most accurate data in the USA on this subject due to the fact that farm workers are covered under the Worker's Compensation law. This results in more stringent requirements regarding medical records and consequently more accurate data. The total of the acute illnesses reported for the manufacturers and formulators, mixers and loaders, air applicators and flaggers, group applicators, and field workers for the mentioned years are 843, 572, 653, 588, 504 respectively. No indication was given about the costs involved in these poisonings, such as medical expenses and days off work.

Fatal accidents, excluding suicides, resulting from pesticides reported in California between 1965 and 1975 accounted for 60 deaths, 6 per year. In Florida, the comparable figure was 19 per year, a total of 150 between 1965 and 1972. Since poisonings depend on an array of factors widely different from country to country it is almost, if not completely, impossible to extrapolate from these data for other countries. However, the figures should give some idea of the magnitude of the problem.

For Australia Conacher and Conacher (1986, p.118) calculate that a pesticide poisoning rate in 1983 of around 30 per 100,000 population is probable. These figures include different kinds of pesticides (agricultural and household); different levels of affection (mild, severe and fatal); and also include suicides (less than 10 per cent of total poisonings between 1971 and 1981, and less than 5 per cent since 1974).

Regarding poisonings in agriculture, Conacher and Conacher (1986) report that '...a number of State surveys of farmers have shown that between 10%

and 25% of farmers monitored (especially orchardists and graziers), have shown positive signs of pesticide poisoning.' (p.124).

2.3.4 Pesticides: long-term effects

Three distinctly different effects should be discussed when considering the long term: the teratogenic, mutagenic and carcinogenic effect (Barnes 1974, pp.147-149; MacPhee 1984, pp.35-42; Elkington 1985).

The teratogenic effect relates to the foetus, resulting in conditions deviating from the norm. The effect of pesticides on the foetus can be fatal. However, since no autopsies are carried out on foetuses after miscarriage in any country (with the exception of Sweden in recent times), no statistics about the causes of foetal deaths are available.

The effects can also be non-fatal, where children are born with defects. One of the problems with teratogenic effects, from an epidemiological point of view, is the fact that environmental defects can not easily be distinguished from genetic defects. Also, with current technology, the detection of subtle changes, such as '...impairment of learning ability, memory, the power of concentration and of intelligence itself...' (Elkington 1985, p.117) is a problem.

Apart from problems with the cause of foetal death Rawlinson (1980, pp.73-74) points out that occurrence of birth defects in full term babies might also often not be recorded. This point seems to be supported by findings of the Toxic and Hazardous Chemical Committee in Sydney (1987). The Committee reported a discrepancy between the frequency of major congenital malformations as reported by the Department of Health, and those of a local group, Women for Health (p.22). The figures of the last group, verified by the National Perinatal Statistics Unit, were considerably higher than those of the Department, which were based on hospital records.

In the case of mutagenic agents genetic material of both germ cells (eggs and sperm) and somatic (body) cells can be changed. When a change in the genetic material occurs the effect can be a miscarriage or offspring with altered genes. Alterations in genes can be inherited in the form of a dominant or of a recessive gene. In the first case, the effect of the mutation is expressed in the next, and subsequent, generations. In the case of a recessive gene, the effect might not be noticed in that generation. However, it can still affect a later generation.

These mutations are not specific. This means that no increase in specific syndromes or groups of syndromes results from this type of mutation. This obviously makes proof of mutations due to specific substances extremely difficult.

The mutagenic capacity of a substance is not always very clear. Enzymes in the body can influence the mutagenic capacity of an agent. This implies that chemicals which are not mutagenic in themselves can be converted into mutagens in the body (National Research Council 1983, p.5). Since people differ in their constellation of enzymes, they also differ in their susceptibility to mutagens. Substances which are non-mutagenic for most people might be highly mutagenic for some (National Research Council 1983, p.6).

Although mutagens can conceivably affect human kind in a positive way, the net effect of an increase in mutation rate is very definitely considered to be negative at an individual level (National Research Council 1983, p.4).

Carcinogenic agents are basically mutagens, except that they affect the genetic material of somatic cells, rather than germ-line cells. Carcinogenicity and mutagenicity are closely correlated (National Research Council 1983, p.1).

An important difference between the short-term and long-term effects of pesticides on human beings is the existence of a so called threshold effect. In the case of acute poisoning, no poisoning occurs below a certain amount (although the amount differs between people), which is called the threshold. However, minimum, safe amounts do not exist in the case of substances causing teratogenic, mutagenic, or carcinogenic effects (Coulter 1983).

In Australia very few studies are available on long-term effects of pesticides. Conacher and Conacher (1981) quote an article in The West Australian (16-5-1980) reporting that a study in the Bunbury/ Bridgetown area revealed that dieldrin (an organo-chlorine insecticide) residues in breast milk exceeded WHO standards by 10-15 times. The source was agricultural pesticides. A similar picture emerged from an earlier study by Miller and Fox (1973), who reported a high presence of three organo-chlorines in human milk in Queensland.

A relatively high incidence of leukaemia and lymphoma has been reported among those involved with agriculture in Tasmania, including workers in the premium orcharding, dairying and vegetable cropping areas. This has been linked with the use of agricultural pesticides (Lickiss et al. 1984).

The Toxic and Hazardous Chemical Committee (1987) discusses problems caused by the persistence of heptachlor on dairy farms on the North Coast of New South Wales. Human health problems in the Coffs Harbour area, possibly linked with the use of dieldrin and weedicides, are also considered.

2.3.5 Feed additives

The main substances of concern here are growth hormones and antibiotics, used as feed additives for livestock. They are of particular concern because they can leave residues in livestock products, such as meat.

Two groups of hormones are used to promote growth in livestock: natural and synthetic. Both are produced synthetically, but the 'natural' hormones (unlike the 'synthetic'), are replicas of the ones which occur in nature. There they occur not only in animals but also in other products (such as eggs and plants) used as food. It is for this reason that many do not see any harm in the use of natural hormones in stock raising.

The use of some hormones in human medicine has been associated with an increase in cancer (Erlichman 1986, p.42). Erlichman reports (p.40) that certain countries which have banned the use of growth hormones '...argue that all hormones - whether natural or manufactured - are highly potent, very complex and little understood substances whose cancer inducing potential has not been fully explored.'

Growth hormones are fed to livestock to increase the rate of growth of the animal, so that less feed and other inputs are needed for the animal to reach a certain weight. In the past these substances have mainly been used in beef cattle and chickens (Erlichman 1986, pp.38-9).

The use of growth hormones in livestock has been suspected of causing an extremely early onset of puberty in consumers of these products (cases of human victims younger than two years have been recorded), with a possible long-term effect on height, fertility and psychological health (Engel 1984; Erlichman 1986).

In Australia approximately three million cattle were implanted with growth promotants in 1985. This '...represents some 45% of eligible animals being treated and some 13% of the national herd.'(Agricultural and Veterinary Chemicals Association of Australia reported 1986, p.2).

Another group of substances, which can be regarded as being in the same category as growth stimulants, is antibiotics. Although they could be considered pesticides in so far as they can be used in the fight against diseases, especially in the chicken and pig industry, antibiotics are also used as growth stimulants (Erlichman 1986, p.44). A very serious consequence of this kind of use is the increased risk of resistance of certain bacteria to antibiotics. The effect could easily be an outbreak of diseases amongst people, with no means left to combat them. Indeed, recent evidence from the United States supports this thesis very strongly (Erlichman 1986, pp.57-9).

Indiscriminate use of one of the antibiotics, penicillin, against mastitis in dairy cattle in South Australia has been reported as being the likely cause of a build-up of resistance in these bacteria, with possible consequences for the human consumer (Jennings 1984b).

2.3.6 Other issues

There are other issues that are relevant to the effects of fertilisers, pesticides and food additives in general.

The first issue is that of a maximum acceptable level of pesticide residue in agricultural produce. In many countries a maximum acceptable level is set for pesticides individually, without taking into account the presence of other pesticides. For example, in Australia agricultural produce is checked on the presence of five organo-chlorine pesticides (see Department of Primary Industry 1987a). These pesticides include DDT (consisting of the subgroups DDT, DDE, DDD), dieldrin, HCB, heptachlor and lindane. For each of these a maximum allowable level is shown. However, no maximum allowable level is shown for the total of organo-chlorines, indicating that the possibility of more than one pesticide being present in samples is not taken into consideration.

A related issue is that of synergism. Synergism is a situation where the effect of two active substances together are greater than the sum of the effects of each of them, as for example is the case with alcohol and histamines. A similar situation can occur with an originally non-active substance which becomes very active after reaction with an originally active substance (potentiation). Very little emphasis is put on this aspect of pesticides when the suitability of the release for public use is evaluated. However, availability of information about the effects of combinations of pesticides, or other substances in combination with pesticides, on human health might not be sufficient to prevent the effects of synergism and potentiation. This is the case because very little information is available about the presence of pesticides in, for example, food. It is therefore likely that the effects of pesticides on human health is worse than officially predicted.

Another issue of importance is that of allergies. Mansfield and Munro (1987) assert that the number of people allergic to agricultural pesticides (often due to its presence on food) is increasing over time.

A fourth issue which pertains to pesticides and food additives is observance of the minimum withholding time of produce following pesticide use. Regulations are needed because pesticides generally cannot be detected by consumers; nevertheless negative effects due to the presence of pesticides do occur. Government regulations (such as the stipulation of a minimum withholding time between time of use of pesticide, and time of possible consumption of the produce) are in force for many pesticides. However, if damage by pests during that time is likely, and enforcement of regulations is unlikely, the temptation for producers to use pesticides in contravention of the regulations must be considerable.

Claims for the safety of pesticides are often based on two assumptions in particular. First, the pesticide industry cannot afford to market produce with detrimental effects. Second, government regulations should be sufficient for the protection of the pesticide user and for the consumer of the agricultural products.

Erlichman (1986, Chapters 5 and 6) discusses both these topics. With regard to the first topic his basic tenet is that the industry's main responsibility is to its shareholders, and that anything legal is acceptable. Since regulations don't always reflect knowledge gained from the latest research, adherence to regulations does not necessarily imply that only those pesticides are used which are considered safe at that time. (See, for example, Walker (1985) who discusses marketing practices in Australia of a distributor of a pesticide, severely restricted overseas on safety grounds, but still widely available in Australia.) A similar point of view is expressed by Weir and Schapiro (1981) who consider pesticide production and sale with regard to developing countries.

Regarding government regulation, Erlichman (1986) discusses reasons for likely faulty regulations or violation of those which exist. He draws attention to the fact that it is unlikely that government bodies are independent from the interests of agricultural producers and pesticide industries. In addition, the desperately small force of inspectors is considered a problem regarding policing existing regulations.

2.3.7 Concluding remarks

Synthetic fertilisers, pesticides and feed additives used in the conventional agricultural production system are potentially harmful to the health both of agricultural producers and of consumers of food. Some characteristics which many of the materials have in common is that their presence is difficult to detect without special equipment, and the effects are difficult to quantify and often long-lasting.

2.4 Soil Quality

The damaging impact of human activity, and in particular of farming, on the soil in widespread areas of the world and over many centuries has been described by authors such as Jacks and Whyte (1939) and Hyams (1952).

Soil degradation problems in the USA due to farming activities have been reported by Lord (1972) and, more recently, by Pimentel and Krummel (1977), Wittwer (1978), the Office of Technology Assessment (1982), and in Canada by Rennie (1979).

In England the Agricultural Advisory Council, at the request of the Minister of Agriculture, Fisheries and Food, carried out an inquiry into the extent to which '...present practices are having adverse effects on soil fertility and soil structure...' (Agricultural Advisory Council 1970, p.1). The Council concluded that there were no problems in connection with 'nutrient fertility' (p.2). However, soil structure was thought to be a different matter, to the extent that '...some soils...cannot be expected to sustain the farming systems which have been imposed on them.' (p.2). Reasons for the problems were said to include a decrease of organic matter, and the use of heavy machinery, often due to '...the adoption of tight cropping sequences on difficult land'.

Hodges and Arden-Clarke (1986) review literature on the relationship between levels of soil damage and farming practices in Britain. Several studies are quoted in which conventional farm management practices (influencing factors such as soil organic matter and degree of soil compaction) were found to cause a considerable degree of land degradation.

In a more recent study Arden-Clarke and Hodges (1988) compare the effect of sustainable and conventional farming on the soil. The physical, chemical and biological effects on soil ecology, soil fertility and nutrient cycles are analysed. In summary it is concluded that the relationship between the different components of processes in the soil is poorly understood, with the effects of conventional agriculture only gradually coming to light. However, '...examination of the comparative effects of conventional and organic farming practices ... should satisfy an objective reader that conventional agriculture poses a far greater threat to soil fertility.' (p.271).

Closer to home some literature is available on the effect of agriculture on soil quality. For a given natural environment, land use and land management are seen to determine the form, extent and rate of land degradation in Australia (Department of Environment, Housing and Community Development Study, 1978).

Although little specific research has been carried out concerning the effect of farming on soils in Australia, several authors acknowledge that existing agricultural practices have contributed to a deterioration in some form or another of the soil. For example, almost all authors contributing to a book on the main wheat-growing soils, red-brown earths, refer to problems with the soil due to the agricultural system (Oades, Lewis and Norrish 1981).

Chartres (1987) also attributes soil degradation in semi-arid areas of Australia to past agricultural practices (clearing and tillage practices). Burch, Graetz and Noble (1987) mention that the inherently low soil organic matter levels, which are reduced by cropping, contribute to structural deterioration of the soil when subject to repetitive mechanical disturbance. As more cropping takes place under conventional than sustainable management on wheat/livestock enterprises, while the number of cultivations per crop is not significantly different (see Chapter 5), conventional farming is likely to be more detrimental to Australian soils than sustainable farming. The recent innovation of herbicides replacing tillage ('minimum tillage') has a positive effect on soil structure as compared to the old conventional system. However, in studies on this technology the effects of extensive use of herbicides on the soil is rarely mentioned.

Conacher and Conacher (1986) discuss the effects of conventional agricultural practices on soils, both overseas and in Australia. In particular, they note the effects on soils of cultivation including: reduction of aggregate stability; increase in bulk density; increase in waterlogging; decline in organic matter and essential nutrients; disruptions to soil organisms; and increase in erosion.

Soil conservation services in the different States emphasise the effect of land use and management on soil. For example, in New South Wales a substantial part of the research carried out by the soil conservation research centres is related to farm practices (Soil Conservation Service of New South Wales 1982). Policies in the different States are to a high degree directed towards farmers, with an emphasis on the provision of information about the cause and prevention of soil degradation.

In summary, the present agricultural production system causes concern for the future quality of agricultural land, both overseas and within Australia.

2.5 Water Quality

Sources of water pollution from agricultural practices are mainly nitrogen and phosphorus fertilisers, animal manures and pesticides.

Increased nitrogen and phosphorus in ground and surface water leads to problems such as nitrates in drinking water, and eutrophication of waterways. The first affects health of people and animals, the second causes a change in use of the waterways.

In a publication by the Organisation for Economic Co-operation and Development (OECD) on water pollution by fertilisers and pesticides (1986) the emphasis was on nitrates in water, caused by agricultural practices. 'International nitrate standards for drinking water are being exceeded by an increasing number of sources in various countries and there is a growing concern over the potential health impacts of increasing nitrate intake by populations.' (p.20). A large part of the problem is caused by intensive livestock husbandry, a practice of little prominence in Australia. However, also nitrogenous fertilisers, the use of which increased five-fold in Australia between 1961-65 and 1981 (p.31), contributes to the problem. Although the total amount applied is small, it is used intensively in some areas, such as in certain parts of Queensland.

Since lack of phosphorus is often one of the limiting factors of production in aquatic systems, increased phosphorus in waterways can lead to dramatic increases in production of algae and macrophytes (Cullen 1974). On a worldwide scale a marked increase in phosphorus concentrations in many natural waters has been recorded (Stumm 1972). This increase is attributed to an increased use of fertilisers in agriculture. In those cases where the water is used, clogging of filters might occur. A change in the aquatic eco-system can also lead to a change in the relative importance of the different fish populations, with consequences for the fish industry or recreational fishing. In extreme cases the oxygen levels of the waters can be reduced to such an extent that fish life is impossible, and consequently mortalities occur (Bayly and Williams 1973). Other effects of the excessive production of algae and macrophytes include aesthetically displeasing masses of algae floating on water, which can add unpleasant tastes and odours to it. Toxicity of such waters to stock and honeybees has been recorded (May and McBarron 1973).

After reviewing the literature on the subject of fertiliser run-off (small plot studies, studies of particular land use units and whole catchment studies) Cullen (1974) concludes that, even though the amount of run-off recorded is low relative to the application, it can easily disturb the aquatic eco-system. Loss of phosphorus by soil erosion is discussed as being an important source of phosphorus in natural waters in Australia. Cook and Williams (1973) report a possible loss of 10 kgs of phosphorus per hectare with every 1 mm of soil eroded. The effect of rainfall on run-off and soil loss in Ginninderra has been measured by Costin (1980), and found to be inversely related to the degree of plant cover. In Victoria, the run-off from fertilised pastures has been attributed by Greenhill, Peverill and Douglas (1983) to slope, previous fertiliser history and inappropriate land management.

In Australia, examples of lakes which need regular treatment for an abundance of macrophytes or which have needed some treatment in the past are: Lake Burley Griffin in Canberra, Lake Wendouree at Ballarat, and Albert Park Lake in Melbourne (Cullen 1974).The Western Australia Environmental Protection Authority (EPA) (1984-85) states that : 'The primary cause [for algal pollution in the Peel-Harvey Estuary] has been over-application of phosphorus fertilizers on agricultural land in the estuary catchment.' Co-operation between the EPA, Department of Agriculture and farmers has ensured the use of less fertiliser, thereby reducing environmental pollution. In general, data for Australian conditions are scant.

Jacobson and Lau (1988) identified five incidents of groundwater contamination in Eastern Australia due to agriculture, mainly fertilisers. They also recognise that there exists a problem with detecting groundwater pollution: 'Many of the known incidents were discovered by accident and there has been little systematic investigation and monitoring of likely pollution sites.' (p.10). An additional problem is the difficulty of detecting contamination (contaminants are often colourless, parameters of pollution not well defined or easily detected by the standard analysis, and subject to a time lag before detection).

Although data on effect of fertilisers on water quality are scant, those about pesticides are even more difficult to obtain. The OECD (1986, p.116) reports:

> 'Data from various countries, through directed research, water-quality monitoring and accident reports, indicate that incidents of pollution of the aquatic environment by pesticides are frequent. Despite the success of the control measures over the past 25-30 years in reducing their number, the incidents which have been reported show that there can be no doubt of a risk to water supplies and aquatic life not only from point sources of pollution, but through accident, misuse or inadequate control of effluents. Moreover, the risk of pollution from normal agricultural use cannot be ruled out. Although the data available are insufficient to permit a realistic assessment of the extent of the risk to water supplies or aquatic ecosystems in OECD Member countries as a result of normal agricultural use of pesticides, such data as there are suggest a need on the part of Member countries at least to explore the extent of the problem, and possibly, even now, to take action.'

An example of pesticides residues found in groundwater due to normal agricultural use is the phenoxyalkynoic acid herbicides in areas of intensive cultivation in the United Kingdom (p.117).

In the US Holden (1986) reported to the Board on Agriculture on pollution in groundwater by field-applied pesticides in four States: California, New York, Wisconsin and Florida. It was stated that 'Groundwater contamination from field-applied pesticides was almost entirely unexpected, particularly since the pesticides being found in groundwater included those generally assumed to degrade or volatilize rapidly.' (p.1). The detection of pesticides in groundwater follows a certain pattern: discovery of a problem at a particular place, expansion in monitoring, and detection of a far greater problem than originally envisaged. This means that it is likely that the problem of water pollution by agricultural pesticides is more extensive than realised at present. Even so, the problem is judged to be serious enough for certain pesticides to be banned in some areas (aldicarb in parts of New York), or the timing and quantity used to be restricted (aldicarb in Florida and Wisconsin). This last point might become such an administrative burden in the future (since in some places decisions were made on a case by case basis) that total banning might become a preferred option. Provision of information about different farm management techniques, including integrated pest management, irrigation and calibration of application equipment, was also considered.

In Australia, the Department of Resources and Energy (1983, Vol.7 pp.47-50, 54; Vol. 8) expresses concern about the degree of pollution in the form of pesticides, along with that of salinity and turbidity, in most of the major river systems. Chlorinated organics were found to be present to varying degrees in the Namoi River Basin, in the Murrumbidgee Irrigation Area, the Murray River, the south-western rivers of Western Australia and in Queensland (p.49). For some, recommended criteria for the environment were exceeded, for others no adverse effects were indicated, although this might have been due to inadequacies in monitoring (p.49). Few reports of the detection of organophosphorus compounds in Australian waters are available (p.50).

The problem of soil erosion and the use of pesticides in sugar cane growing areas in Queensland have been blamed for deterioration of the Great Barrier Reef (Stone 1982).

In summary, although not much research has been conducted in the area of environmental pollution due to agricultural production in Australia, there is evidence that fertilisers and pesticides do pollute waters.

2.6 Other Issues

Although the main on-farm problems caused by the conventional agricultural system are related to pests and soil, several other issues are relevant in this context.

As mentioned in Section 2.3.2 nitrate levels in water supplies and plants affect livestock. Hodges and Scofield (1983a) quote research in which the effect of nitrate on stock is reported, including acute poisoning of ruminants; irregularities of reproduction and lowered milk yields; increase in milk fever in cows; and changes in thyroid metabolism. Effects of high rumen ammonia are reported to include a reduced availability of magnesium.

In the same review nitrogen and potassium fertiliser were related to the incidence of tetany, and the use of phosphatic fertilisers to copper deficiency in cattle. In other research the botanical composition of the pasture was found to be important in connection with the reduction of proneness to tetany. Also many studies are quoted which support the view that the use of fertilisers influences the composition of pastures and plants. Fertiliser use on pasture often results in an agricologenic effect, through increased susceptibility to diseases, deficiencies of certain minerals or vitamins, and increased toxicity. This management technique obviously is relevant to the quantity (and possibly the quality) of farm output produced.

Plants are not only influenced by fertilisers. Hodges and Scofield (1983a) quote several studies in which herbicides are reported as increasing the nitrate content of plants.

In Australia some research has been carried out on the effect of pesticides on crops and livestock. Dubey (1970) described how pesticides affected soil microbial population, inhibiting the N mineralisation, which resulted in a severe N starvation of the sugar cane crop.

Elliott, Lumb, Reeves and Telford (1975) examined yield losses in weed-free wheat and barley due to post-emergence herbicides. It was found that in eight of nine generally used herbicides, a reduction of yield from 5 to 6 per cent was common at commercially used rates (p.110).

Reduced yields of some crops due to the use of pesticides were also discussed by Herrmann and Fawcett (1985). These researchers found that yields of several genotypes of medic varieties, peas and beans were depressed several years after the application of residual herbicides at some locations in South Australia.

Eberbach and Douglas (1983) mention that Atrazine, Amitrole and Roundup can persist in sandy Mallee soil in Victoria for 120 days. This was indicated by reduced N-fixation (acetylene reduction) associated with subclover.

Damage in several crops, including wheat, has been reported with commercial herbicide application rates (The Land, 19 May 1983). Several reports of crop losses due to spray damage on cereals and lupins appeared in Western Australian newspapers in 1984-85 (see for example Zekulich 1984; Stock Journal, 20 September 1984). In Queensland, crop damage due to spray drift and inversion was considered to have caused sufficient damage to crops in the past for an extension agronomist to warn about these dangers in a farmers' newspaper in 1984 (Bullen 1984).

2.7 Concluding Remarks

The problems discussed in this chapter are a combination of private and external costs of conventional farming.

Although no quantification was attempted of off-farm costs of conventional farming through its effect on pest resistance to pesticides, human health, and soil and water quality, it is clear that costs can be considerable. Estimates of external costs of pesticide use in Australia are not available. However, because of the relatively small role of intensive crop and animal production in Australia, it is likely that external costs are lower than in many other high income countries.

Even though external costs of conventional farming in Australia might be low compared to other countries, the question to be answered is whether there is an alternative form of agriculture which is socially superior to conventional agriculture. The alternative form examined in this thesis is what is referred to here as sustainable agriculture. In the next chapter the term is defined, some concepts expanded upon, and production practices explained. In addition, a few studies are examined to consider sustainable agriculture in some detail.

3 SUSTAINABLE AGRICULTURE

3.1 Introduction

Although there are problems associated with conventional agriculture, it is not necessarily true that a better form of farming can be practised. However, some producers maintain that they can farm without the inputs which cause many of the problems in conventional farming. What kind of agriculture is this? How is it different from conventional farming? And in which way can these farmers 'manage'? Are their returns to farming similar to those of conventional farmers in the short-run or long-run? Do they drop their standard of living, or do they receive a large part of their rewards in psychic income?

In this chapter the kind of agriculture referred to in the previous paragraph, and called sustainable agriculture in this thesis, is defined first. Details are provided about the techniques used by practitioners of this kind of agriculture. The difference between sustainable and conventional farming is discussed next, with a difference in the approach to farming between the two systems being highlighted.

Because of this difference in approach, a comparison between the two types of agriculture needs to be based on the whole system, and not on particular aspects, such as crop yield due to a difference in application of fertiliser and manure. Whole-farm comparisons are the subject of this chapter. A more extensive, albeit less detailed, review can be found in Lampkin (1986a). Only the private costs and benefits for one year in some, or a few years in other studies, are examined. Long-term effects, such as improved soil quality after a number of years, are not considered.

3.2 Definition

The alternative method of farming, in which no synthetic fertilisers and pesticides are used, is known under many names - including alternative, organic, biological, ecological, natural, low-input and sustainable. The National Association for Sustainable Agriculture, Australia (NASAA) (1986), which refers to it as sustainable agriculture, defines it as:

> 'A system of agriculture able to balance productivity with low vulnerability to problems such as pest infestation and environmental

> degradation while maintaining the quality of land for future generations.
> 'In practice this involves a system which avoids or largely excludes the use of synthetically compounded fertilisers, pesticides, growth regulators, livestock feed additives and other harmful or potentially harmful substances. It includes the use of technologies such as crop rotations, mechanical cultivation and biological pest control; and such materials as legumes, crop residues, animal manures, green manures, other organic wastes and mineral bearing rocks.'

Similar definitions have been provided by others (for example, US Department of Agriculture 1980).

Although sustainability can be defined in different ways (Tisdell 1988), in this thesis the name 'sustainable agriculture' is used to indicate the alternative form of agriculture in which no synthetic fertilisers and pesticides are used, and in which other techniques to cope with soil fertility and pest problems are included. Farmers who use this production method are called 'sustainable farmers', their farms 'sustainable farms' and their produce 'organic produce'. In the literature review or where other work is referred to or quoted, the terminology of that work is maintained.

3.3 Techniques Used in Sustainable Agriculture

The two main areas of concern in agricultural production are soil fertility and pests. In conventional agriculture these two concerns are dealt with by using synthetic fertilisers and pesticides. Which techniques do farmers employ when the use of those inputs is not acceptable?

In sustainable farming the emphasis of the management system is on the soil. The main focus of sustainable farmers is on obtaining and maintaining a healthy soil, in order to influence the health of crops and stock, thereby preventing the occurrence of some pests. In essence, sustainable agriculture is a system of agriculture in which the aim is, by improving or maintaining the soil quality, to provide the nutrient requirements of crops and to prevent outbreaks of pests and diseases. Many of the techniques used in sustainable agriculture are therefore directed towards the soil. They include the application of organic wastes (including crop residues, animal manures, and off-farm wastes) and of relatively insoluble inorganic materials (such as rock phosphate), and the inclusion in the rotation of green manures (mainly leguminous crops grown to incorporate in the soil at a particular (green) stage of their development) (Arden-Clarke and Hodges 1988, pp.227-8). This is in contrast to conventional practices of using water-soluble fertilisers to feed the plant, as opposed to improving the soil.

As mentioned in Section 2.2, avoiding application of synthetic fertilisers decreases the incidence of pest attack, thereby reducing the need for pest management. However, other techniques are also used in sustainable agriculture to prevent an outbreak of pest problems, or to cope with them when they occur. They include: crop rotations; strip cropping (where strips of land are planted to different crops); intercropping (where different crops are planted together); provision of vegetation (hedges, trees and other plants) for birds and insects which prey on pests; and the use of trap crops and pheromones (crops and substances which attract pests away from the commercial crop). In the case of diseases, resistant crop varieties and animal breeds and (in some cases) the organic matter content of the soil prevent or minimise problems.

Weed control is often carried out by mechanical means, with timeliness having a considerable role. Other techniques used include: delayed planting; crop rotations selected to minimise weed growth; cover crops (to reduce weed growth during a break in cropping); crop varieties which crowd out weeds at the early stages of growth; use of insects or other organisms which attack weeds; and mulches.

The use of crop rotations to minimise weed growth incorporates the notion of allelopathy, the biochemical interactions between plants and other living organisms. This technique, as with some others, is used in controlling pests as well as weeds (see, for example, Rice 1983).

3.4 Difference Between Sustainable and Conventional

It is sometimes said that the difference between sustainable and conventional agriculture is a matter only of degree and that they are not different systems. One of the arguments is that, even according to the definition of sustainable agriculture, inputs used in conventional agriculture may be used in sustainable agriculture (albeit in decreased quantities). In addition, those inputs or techniques advocated by sustainable growers are also used (possibly to a lesser extent) by conventional farmers.

In this argument the use of inputs or techniques per se is the only criterion according to which the two methods of farming are judged. However, it is important to recognise that 'The different approaches to the problem of plant nutrient supply in conventional and organic farming systems is as much a product of conceptual differences in attitude towards the soil and the agricultural eco-system, as of differences in materials, methods and techniques.' (Arden-Clarke and Hodges 1988, p.227).

Restrictions on farm inputs and techniques are prominent in the definition of sustainable agriculture. However, sustainable farming is not conventional farming without the use of synthetic fertilisers and pesticides. A farm on which only the elimination of these inputs has occurred is not certified as a sustainable farm under NASAA production standards (1989). Such a certification is only granted when the whole system is seen to be geared to address potential nutrient deficiencies and pest problems (see Section 3.3).

The main aim of the restrictions regarding the type of inputs allowed or disallowed is to maintain a healthy soil, with consequent beneficial effect on crops and stock. If pest problems still occur, the use of (some) synthetic pesticides may be allowed in certain circumstances. The emphasis of conventional agriculture, however, is on minimising or 'eliminating' pests and diseases once they occur, although prevention has some place in this management system.

In conclusion, the two approaches to farming can be considered as basically different from one another. In sustainable agriculture the emphasis is on the prevention of problems, which is attempted by considering the whole system. Resulting output is regarded to be at a level which can be sustained. In conventional agriculture the emphasis is on output, with problems which occur in the process being dealt with as they arise. The two approaches to farm management are therefore treated as two different systems in this study.

3.5 Comparison of Sustainable and Conventional Farming[4]

3.5.1 Introduction

Research reviewed in this section includes studies from the UK (Murphy 1975; Vine and Bateman 1981), The Netherlands (Cleveringa 1978), USA (Klepper et al. 1977; Lockeretz 1981), Australia (Conacher and Conacher 1982) and New Zealand (Gunning and Cullen 1983). In some of the studies sustainable farms only are included. In others also semi-sustainable (those on which synthetic fertilisers and pesticides are used to some degree) are examined. No effort was made to cover all surveys. Rather, those included should be considered as examples. Murphy's (1975) was one of the first to be conducted. Klepper et al. (1977) and Lockeretz (1981) are two of the most quoted studies in this context. Vine and Bateman (1981) surveyed a substantial part of the British organic growers. Cleveringa (1978) was included for the detail of the analysis. Conacher and Conacher (1982) and Cullen (1983) are topical from an Australian point of view. As the last two are qualitative studies only, they are incorporated in Appendix 1.

The studies are divided into two categories: crops and mixed agriculture, and livestock. In Section 3.5.2 the quantity (yield) of agricultural produce is compared between the two systems. As quality was not analysed in the studies mentioned, a long-term experiment detailed in Balfour (1975) is reviewed (Section 3.5.3). To consider the financial aspects of the two systems, the quantity produced and prices of inputs used are discussed in Section 3.5.4. One of the inputs not treated extensively in these studies is information about the management system, which can add value to other inputs or to outputs. Because the need for and availability of this input differs greatly between the two management systems, it is discussed in more detail in this section than the other inputs. Output prices are examined in Section 3.5.5, and returns to farming (outputs minus inputs) in Section 3.5.6. Details are discussed in Appendices 1 and 3, while summaries (with the exception of 'information' and 'output prices') are provided in this section.

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[4] See footnote 2.

Two points need to be stressed in connection with the surveys. First, most of the studies reviewed are case-studies. This means that no statistical inferences can be drawn for the total farming community on the basis of these results. In other words, the results in these cases do not establish (in a statistical sense) anything about sustainable agriculture. Rather, they allow an insight into the possibilities offered by sustainable farming.

Second, in case-study comparisons measurement of managerial skill is a problem. In some of the studies reviewed, the differences in management were not accounted for. As managerial skill is an important factor in the financial results on a farm, differences in results could be attributed to this factor, instead of to the difference in farming systems used. In a few studies this problem was partly solved by comparing the sustainable farms with conventional farms on which the best results were achieved (Klepper et al. 1977; Cleveringa 1978). However, from the point of view of the comparison, this is still a somewhat unsatisfactory solution, since the management skills of sustainable farmers might be less than that of the (proven good) conventional managers.

3.5.2 Quantity of farm products

From the three studies in which crop yields were examined (Murphy 1975; Klepper et al. 1977; Vine and Bateman 1981) it is clear that yields on sustainable farms can be similar to those on conventional farms. Relative yield performance is not necessarily the same for all types of crops while, within crops, it can be affected by weather conditions. For example, Klepper et al. (1977) postulated that, in climatically favourable years, the yield difference between the two systems was less for oats than for wheat. Also, the wheat yield under organic agriculture was found to be similar in a climatically adverse year to that under conventional agriculture (see Appendix 1). In a climatically good year yields on an organic farm were lower.

In two of the three surveys in which livestock was the main enterprise, lower yields per hectare were found on sustainable than on conventional farms (Cleveringa 1978; Vine and Bateman 1981). In one survey higher yields were recorded on the sustainable farms (Murphy 1975).

The comparison of yield *per se* as a measure of soil fertility or returns to farming, however, is meaningless. This is because yield figures do not show inputs used, nor total farm production. Incorporation of inputs in output figures relates to the concept of 'net yields'; rotations are relevant in connection with total farm production.

Kiley-Worthington and Rendle (1984) define net yield as gross yield minus nutrients obtained off the farm for the soil and/or feed for stock. In that way 'imported' inputs, such as fertilisers and feed, which can boost productivity figures per unit of land considerably, are accounted for. For example, it might appear that productivity per hectare in a feedlot is very high. However, few will dispute that this is the wrong way to measure productivity: the importance of the amount of feed bought is apparent in such a situation. Although many cases are less extreme, bought feed and soil nutrients should be accounted for to get an accurate picture of the capacity of the soil. It is for this reason that in the tables in Appendices 1 and 2 figures for additional feed and fertiliser are shown for livestock enterprises. For cropping, sustainable farmers were selected on no or minimal use of fertilisers, and figures for use of that input are therefore not supplied.

The significance of rotations in this context relates to the fact that land can be taken out of production of cash crops for some time, and so allow a build-up of soil fertility. This has a positive effect on the yielding capacity of the soil. Also the total productivity of the farm is affected by such management decisions.

As cash inputs and total physical production are reflected in the financial returns to farming, financial measures might show a more complete picture of farming than yield figures do.

3.5.3 Quality of farm products

Quality of farm products is related to the nutritional value of the product, and to the presence of substances which can affect the consumer. As the direct effects of fertilisers and pesticides on human health are discussed in Section 2.3, the presence of these materials on food is not touched upon here. What is under consideration is the nutritional value of food and feed produced in the different management systems.

Hodges (1981), in a review of the available literature on the quality of produce grown under conventional and biological methods, quotes several studies in which certain quality characteristics (such as vitamin A and C levels, nitrogen levels, dry matter, and storage ability of several crops) were found to be similar when grown under the different systems. In other studies differences in quality between the two systems were found. The question then was posed whether it is possible that such divergent findings can all be true. In his conclusions he postulates that, for alternative systems to show any effect, they must be 'mature' systems, that is, systems which have had time to establish an equilibrium of all involved organisms. The second explanation put forward concerns the method of measurement. In many of the studies where no difference between the systems was found, analysis was usually performed in the form of chemical estimation of various nutrients. In those where differences were found, the 'biological performance' (for example livestock growth on a certain amount of feed) was typically measured.

One of the classical examples of a comparison of product quality, in which a 'mature' system was examined, and where the biological performance of the system was measured, was published by Balfour (1975). Balfour described an experiment which was started in 1939. A farm was divided in three parts. One of the parts was farmed organically, and two in the conventional way: one with and the other without livestock. No inputs from outside were allowed, except for the fertilisers and pesticides on the conventional farms. No products left the farms except livestock products. This means that crops were grown, and fed to the livestock (except on the part without livestock) in order to measure the quality of the crops. The result was that, although crop yields on the organic farm were often lower than on the conventional farms, livestock output was similar or higher. The experiment indicates that crop quality on the organic farm was such that a smaller amount of it than of the conventional produce was equally productive in terms of livestock output. Details of this study are provided in Appendix 2.

Although the research represents only one case study, the results illustrate that measurement of quantity of product only may lead to wrong conclusions about productivity.

3.5.4 Farm Inputs

Inputs can be divided into two groups: variable and fixed. The distinction between the two groups is the degree to which they can be varied. Since this is dependent on the time period under consideration, the inclusion of a particular input in one of the groups is necessarily subjective to some extent. However, in general, fertilisers, manure, pesticides, seed and casual labour are considered to be variable inputs; land, buildings, machinery and permanent labour are fixed. Information is a special kind of input, which can add to the value of other inputs and to outputs.

3.5.4.1 Variable inputs

3.5.4.1.1 Fertilisers, manures, feed and pesticides

The definition of sustainable agriculture explicitly names fertilisers and pesticides as inputs which are not, or sparingly, used in the production process. Thus, in general, expenses for these inputs are lower for producers in the sustainable system than for those in the conventional system. However, use of manures and other organic material which, due to their bulkiness, are relatively expensive to transport and handle, entails an expense for the sustainable sector usually not incurred by conventional farmers. Non-availability of some fertilisers allowed in sustainable agriculture may also mean higher transport cost, and consequently higher total prices, for sustainable farmers.

As discussed above, feed imported onto the farm should also be mentioned when soil productivity is discussed. Since crops produced on (mixed) farms are often used at least partly as stock feed, lack of soil fertility can be compensated for by buying feed. Fertiliser, manure and feed are therefore substitutable to some extent, and should be treated in the same category.

In some of the studies in which costs of fertilisers were mentioned, it was not stated whether these costs were for fertilisers allowed under sustainable agriculture or for synthetic fertilisers (in which case farmers would be semi-sustainable). Terminology used in the original work is adhered to here.

On the cereal enterprises in Murphy (1975) one of the three sustainable farmers did not use any fertilisers and pesticides. The other two farmers spent 10 and 19 per cent as much as the conventional farmers on these inputs on wheat, and between 36 and 80 per cent as much as conventional farmers (mainly for fertiliser) for spring barley.

The sustainable dairy farmer in Cleveringa's case study (1978) spent between 30 and 45 per cent of the conventional farmers' expenditure on fertilisers, manures, and (mainly) feed.

Vine and Bateman (1981) discussed the variable costs for wheat and barley farmers. Of the 10 comparisons of wheat production, 4 sustainable farmers bought no fertilisers, manures or pesticides, 3 bought 10 per cent or less than that of the standard with which they were compared, and 3 bought between 28 and 71 per cent. The percentages for barley were higher, with 1 out of 6 spending nothing on fertilisers, manures and pesticides, and the other 5 spending between 10 and 71 per cent of the standard, mostly on fertilisers and manures.

3.5.4.1.2 Credit

Differences in credit facilities (interest rate and available quantity) between the two systems are possible. This would mainly be due to the fact that sustainable agriculture is not widely recognised as an acceptable farming system, so that credit institutions would consider it to be risky.

Data on credit availability to sustainable farmers is almost non-existent. In the USA Blobaum (1983) surveyed sustainable farmers in the Midwest on barriers to conversion, and concluded that credit availability might not be a big problem for sustainable farmers. However, although this group of producers was much less dependent on credit than their conventional counterparts, almost 40 per cent of the relevant answers indicated that sustainable farmers felt that '...organic farmers in general are discriminated against or treated unfairly by lending institutions' (p.275).

3.5.4.1.3 Fuel

Fuel is used for different activities on sustainable farms than on conventional farms. The main differences are in seed bed preparation, and weed control (by mechanical means or spraying).

However, it is not obvious in which system most fuel would be used. Vine and Bateman (1981) found that less was used in the sustainable than in the conventional system.

3.5.4.2 Fixed inputs

3.5.4.2.1 Machinery

It is not clear whether a difference exists in cost of machinery available on sustainable and conventional farms. Lockeretz et al. (1977) found that the size of the machinery employed on the 14 matched pairs of the survey was comparable. Vine and Bateman (1981) looked at the total cost of machinery, power and contract operations, and concluded that the average cost on sustainable farms was about 20 per cent less than on conventional farms. The reasons for such decreased use of this inputs are not clear, and are explored in Chapter 5.

3.5.4.2.2 Labour

It is sometimes asserted that in the sustainable system more labour per hectare is employed than in the conventional system (see Lockeretz and Wernick 1980). However, this will depend very much on the type of enterprise under consideration. Of the few studies reviewed here which have incorporated this aspect of farming, differences in the two systems are not obvious. Murphy (1975) refers to relatively high labour costs on sustainable farms without giving details. Klepper et al. (1977) found that three per cent more labour per hectare was needed on sustainable farms than on conventional farms. Vine and Bateman (1981) reported a lower paid labour component on sustainable farms than on conventional farms, but equal total labour (including the farmer's and spouse's labour). It is likely that relative labour requirements differ greatly between industries.

3.5.4.3 Value adding input

3.5.4.3.1 Information

In connection with information, two stages can be distinguished. First, information needs to be gathered, by producing new knowledge or locating existing knowledge (research), after which dispersal (extension) can take place. In this section characteristics of research and extension are considered in so far as they are relevant to conventional and sustainable agricultural systems. However, it is not the intention to quantify any of the issues. The inclusion of this section is intended only as a basis on which to assess the level of potential of the two systems, given the past level of research into each of them.

- Research

Information about agricultural practices can be considered a public good (defined by Pearce (1976, p.20) as non-excludable and non-rival). 'Non-excludable' is defined as a situation where no mechanism exists '... whereby the good can be priced or rationed so as to prevent other people from enjoying the benefits of the good'. 'Non-rival' means that consumption of the good by one person does not preclude its simultaneous consumption by another person.

An example of non-excludability is knowledge about the optimal planting date for a specific crop. Although the first person who wants to find out may be willing to pay for this knowledge, that person could not be prevented from 'spreading the word'. Once publicly known, nobody will want to pay to obtain the knowledge. This knowledge is also non-rival because the provision of information to one person does not reduce the amount of information available to others. Public goods are rarely provided by the private sector, mainly because of the characteristic of non-excludability.

Research can be carried out by the public or private sectors. In general the private sector invests money in applied research concerned with private goods. Public money is often allocated to research relevant to public goods, of which 'basic research' is a component. Consequently, ceteris paribus if research paid for by public monies is approximately equal for both systems, more research is conducted into an agricultural system with a relatively high component of inputs which are private goods, than into one in which a relatively high proportion of inputs are public goods.

Comparing the sustainable and conventional farming systems, it is obvious that in conventional agriculture more inputs are used which are private goods. Fertilisers and pesticides are examples. To compensate for the absence of these, sustainable producers rely inter alia on the following practices (see also Section 3.3): crop rotations; management systems which emphasise the production of organic material to be used for the build-up of soil structure and fertility; use of stock, not only for its output in saleable products like wool and meat, but also for manure production and its capacity to reduce weeds; biological control of pests, disease and weeds; and manipulation of planting dates to reduce pests, weeds and diseases. All these practices require more than the straightforward application of purchased inputs. They require the use of the public good 'knowledge'. Although in conventional agriculture these knowledge-demanding practices are also used, there is a reliance on fertilisers and pesticides. There is therefore little demand for alternative possibilities to cope with soil fertility and pest problems. Consequently, relatively little effort is put into developing these technologies. For a discussion of the issues see also Oelhaf (1978), and Tisdell, Auld and Menz (1984).

One way to find out about research priorities in the past is to analyse the percentages of papers published on particular subjects over a certain period of time. Lovett (1982) categorised research as applied to major crops from 1929 to 1979. The journals reviewed were Biological Abstracts (from 1929 to 1944) and Field Crop Abstracts (from 1949 to 1979). Of all the crops together almost 60 per cent of the topics were covered by crop agronomy, adaptation and physiology. Pests, diseases and weeds were the topic of 8.0 per cent of the articles; pests, diseases and pesticides of 4.5 per cent; and weeds and herbicides of 2.5 per cent. In contrast crop rotations and biological control, areas important in sustainable agriculture, featured in 1.6 per cent of the articles (1.3 and 0.3 per cent respectively).

It should be noted that the aggregation of data does not allow for the discussion of a trend of research in the different areas. However, since synthetic pesticides were not used on a large scale before 1945, it is fair to say that the figures regarding percentages of articles produced on pesticides are quite likely to be relatively low, as compared to percentages if data from 1949 onwards only were used.

The data also do not indicate whether recently more research has been directed away from pesticides. However, in two journals in which articles on weeds are published, Weed Science and Weed Research, 69 per cent and 73 per cent respectively of all the articles published in 1978 involved the study of herbicides (Lovett 1982).

Since relatively much research has been carried out into conventional farming, it is likely that conventional producers farm closer to the potential of the system (within the current technological possibilities) than sustainable growers. For example, crop varieties have been bred for high yielding capacity under conditions of fertiliser and pesticide applications. Since weedicides are available, it is not likely that crop breeding has extended into, for example, combining the characteristic of vigorous vegetative plant growth in the initial stages (to smother weeds) with high yield, a variety of interest to sustainable farmers. This means that, although the technology is available to cater for the needs of sustainable farmers, they are likely to forego more income due to lack of research than conventional farmers. In addition, it is probable that sustainable farmers spend more of their resources on the gathering of information than their conventional counterparts. For example, more effort needs to be made to secure the available information by means of finding relevant books and magazines. Attendance at conferences and visits to the properties of like-minded producers might also be more time consuming and costly than for conventional farmers. However, of most importance in this connection may be the need for sustainable farmers to carry out experiments on the farm, which can be time consuming and risky.

Sustainable management techniques involve incorporation of local conditions in farming to a much larger extent than conventional techniques. For example, weedicides can be, and are, imported from overseas to work under Australian conditions. Although general principles of techniques such as biological weed control (a technique used in sustainable agriculture) can be learned from overseas sources, research still needs to be carried out within Australia to control weeds. The appropriate insect to control the weed, for example, will need to be tested for Australian conditions before it can be released in order to ensure that damage to non-target organisms is contained. This means that, since technology used in conventional agriculture can probably easier be imported than that used in sustainable agriculture, more spending may be needed on research for sustainable than for conventional agriculture to obtain the same kind of results. However, too many variables are unknown (such as return to investment and cost of importing) so that a categorical statement about the matter is premature.

The difference in allocation of private research into the different farming systems, ceteris paribus, may have far-reaching consequences. This is due to the fact that technologies often have a large element of indivisibility in them. That is, the investment can only be made 'as a whole'. For example, the decision to use weedicides involves not only the purchase of the material. Spraying equipment and tractor power to pull it is needed, and the provision of a storage place for the material, equipment, and tractor. The decision to use one kind of technology for part of the farm has consequences for other parts. For example, once the necessary equipment for the application of weedicides is available, sprays against pests and diseases can be used for relatively low marginal costs. In such a situation carrying out a biological control program for those other problems may decrease net private financial benefits as compared to using pesticides.

As research into public goods are underfunded, ceteris paribus, compared to research into private goods, technologies are likely to be adopted which are not socially optimal. This can lead to distortions in resource allocation which are likely to reinforce themselves; the result can be a cumulative misallocation. Although each subsequent decision about research to be undertaken might be an economically efficient decision in the context of the existing structure, an overall inefficient system may still be developed.

The direction of research is also influenced by other factors such as political power and vested interests which are, to a certain extent, overlapping forces. Hadwiger (1982) argues that in the USA 'Congress has worked its will on research policy primarily through the power of the purse.' (p.115). Appropriation of funds is often related to the interests and commitment of particular members of the relevant fund appropriation committees. In connection with one of these committees, the House Appropriations Subcommittee on Agriculture, Hadwiger (1982) states that it '...wields major - some would say irresistible - influence over research decisions. It is a "one man" committee, the man being its chairman for several decades, Congressman Jamie Whitten....' (p.125). Whitten became a member of the committee in 1942, and its chairman in 1949. He stayed in that capacity at least until 1982, with the exception of 1953-54. The two issues specifically mentioned by Hadwiger as considered by Whitten not to be worthwhile funding were social and environmental consequences of technological change. A good example of his thoughts about the use of pesticides is his attack on Carson's (1962) publication on problems related to the widespread use of pesticides (Whitten 1966). The use of pesticides in Australia is a technology imported mainly from the United States.

Also private industry influences the direction of public research in the United States (Hadwiger 1982, p.106). The reasons for this influence include several factors. One, direct funding of research in public institutions is quite common, sometimes only to a small degree in order to get a project started, or in the form of underwriting of prizes to 'successful' researchers. Two, the employment of researchers working in public institutions as consultants for an industry is commonly accepted. This secures links between these institutions and the private industry.

A similar situation exists in Australia. The total funds provided by the Rural Industry Research Funds (RIRFs), funds raised from an output levy often matched by Commonwealth money, to research organisations is relatively small. Jarrett and Lindner (1982) state that these funds are mainly used '...to finance operating expenses and, to a lesser extent, capital expenditure, while leaving salary costs to be financed from direct Treasury subvention.' They continue: 'Given the fixed nature of research personnel, this policy has allowed the RIRFs to exert an influence over the direction, but not level, of rural research far exceeding their contribution to rural expenses.' (Jarrett and Lindner 1982, p.92). Although RIRFs are administered by output industries it is likely that, due to past training and experiences of the administrators, research is directed towards conventional agriculture.

In summary it can be said that, due to several factors, research on methods of conventional farming is more likely to receive funding than research in sustainable farming methods. These factors include the nature of the inputs in agricultural production (private as opposed to public goods); indivisibility of technology; political factors; and vested interests.

- Extension

Dispersal of information gathered via research takes place in several ways, some of it through the public sector, and some through the private sector. Dispersal of information by public funds is carried out by education institutions, officers of the Department of Agriculture and by some radio and television stations. The private sector includes: stock agents and other retail outlets; sales representatives of the agricultural input industries; and radio, television and newspapers through advertisements and articles. Producers also obtain information from other producers.

Most of the agricultural education in Australia is based on conventional agriculture. Officers of the Departments of Agriculture are usually recruited from graduates of universities or agricultural colleges. There are several reasons why it can be expected that the bulk of the attention of these extension officers will be taken up by information about the conventional system. One, there is likely to be a lack of familiarity with sustainable agriculture. Two, it is likely that there is a cost to the officer related to involvement with what is generally considered to be an inferior agricultural system. Costs incurred by extensionists are in the form of a lowered status amongst colleagues and a decreased chance of promotion due to a 'display of non-professionalism'. However, in recent times, this attitude is changing somewhat in Australia.

With regard to the private sector, it is to be expected that information is supplied about products developed in that sector, or about products to which theirs are complementary. As a general rule traded inputs, for which substitutes exist, are promoted relatively heavily. For example, for a number of weeds several different kinds of herbicides can be used, and would therefore be advertised. Different equipment to apply the sprays would also be publicised.

In the sustainable system, where part of the weed problem is combatted within the rotation system, no advertisements remind anybody that that is a possible way to tackle it. Thus, information about a privately traded good is more likely to be noticed than information about a public good, for which no advertisements are made (see also Oelhaf 1978).

Information can also be dispersed by means of newspapers, radio and television. Some are privately owned, others are public channels of communication. For earlier-mentioned reasons of likely lack of familiarity with the subject, status and opportunity costs, the media are also likely to have a bias towards the conventional method of agriculture. The degree of dependency on advertisements from a particular kind of input industry might also be a factor in the way of reporting.

In summary, strong forces are at play which keep the market for agricultural research and extension far from a market of perfect competition. These include: the existence of public goods; institutional bias towards the conventional farming system; opportunity costs for those involved in research and extension; and the presence of vested interests. Consequently, misallocation of resources from a social point of view is likely.

3.5.5 Output prices[5]

The difference in price between sustainable and conventional produce is based on differences in quality as perceived by buyers, on the consumers' willingness to pay (which is influenced by income and taste), and on availability of organic produce (possibly influenced by institutional arrangements).

At this stage it is not clear to what extent the price differentials between products of the two systems are due to the perceived differences in quality between sustainable and conventional products (Geier and Vogtman 1984) or to other factors, such as institutional arrangements. For example, in the past in The Netherlands the ecological movement set (regional) producer prices for the forthcoming season based mainly on estimates of production costs, and on current prices in the conventional

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[5] Parts of this section are published in Wynen (1988b).

and bio-dynamic market. It then estimated the production needed to satisfy the expected demand associated with these prices, and gave verbal guarantees that it would buy that amount from the existing producers (Nieuwendijk 1983, p.26). This effectively limited the number of producers allowed to use the ecological trademark and hence the extent of the total production, which influences prices.

According to trade sources, organic produce was bought in the past mainly by those who had allergies to pesticides. For this reason willingness to pay high prices (and hence inelastic price elasticity) was likely at that stage. However, another category of buyers possibly responding more to prices has joined this group. Although little research has been carried out on this topic, that available indicates a positive correlation of consumers with high incomes and a high level of education (likely to be dependent) (see, for example, Van der Valk and Van der Weele (1987)). As this group is less dependent on organic produce for their health, it is likely that price elasticity is high relative to that for the allergy sufferers.

Up until the recent past, sustainable agriculture was not considered a viable option by most farmers, and thus the supply was restricted. This led to relatively high price differences between organic and conventional produce.

Prices for sustainable produce relative to conventional prices differ greatly between countries and between kinds of produce. For example, in The Netherlands the average vegetables and fruit prices at retail level were approximately 30 per cent higher for organic than conventional produce (Nieuwendijk 1983, p.13). Geier and Vogtman (1984) conducted a survey amongst 14 conventional, 14 bio-dynamic and 14 organic-biological farmers in the southern part of West Germany. On average, prices paid for produce sold at the farm gate for a 'sustainable basket' of food were 30 per cent higher than those paid for the same conventional produce. Differences between product prices in the two sectors was marked, ranging between 183 per cent for alternatively grown wheat and rye, compared to the conventional products, and a minimum of -12 per cent for carrots. However, the bio-dynamically grown carrots were mainly juiced, so that the comparison may not have been between the same products. Premiums between 20 and 30 per cent for sustainable produce were common.

The increased demand for organic produce preceded the increase in supply, both overseas and in Australia. Current high prices reflect this situation. With an increase in supply, prices are likely to decrease. With promotion and increased consumer confidence in the product, however, the potential exists for increased demand and continued high prices.

The export markets where Australia is most likely to sell organic produce are the developed countries where incomes are relatively high. The demand for organic produce in potential export markets is expected to increase in the foreseeable future. The Danish Ministry of Agriculture (1986) carried out research into the marketing possibilities for organic produce. One of the big stores in Denmark (FDB) which has sold organic produce since 1980 expected in 1986 to be able to sell 10 times as much in 1988 as in 1986, and 50 times as much in 1991. Most of the organic produce was potatoes, onions and carrots. Denmark expected that in the short term it would still be importing organic produce, and that in the medium term it would be exporting to Great Britain, West Germany, Sweden, The Netherlands and France.

According to the report, 1 per cent of the total turnover of the food market in Great Britain consists of organic food, with a growth of 25 per cent per year in the organic market. It is expected that in 1995 10 to 20 per cent of the total food market will consist of organic food. At present 60 to 75 per cent of supermarkets' sale of organic produce is imported. Prices depend on product and region, but an average of 40 per cent higher prices than those for conventional products are quoted. As in Denmark, supermarkets in Great Britain (such as Safeways) are selling organic produce.

A big supermarket chain in The Netherlands (Albert Heijn) expects to be able to sell organic produce at prices which are 50 per cent higher than those of conventional products. A major concern of chain stores, both in The Netherlands and in Germany, is reliability of supply. Buyers are looking for imports if a steady supply cannot be guaranteed from domestic sources.

In summary, it is expected that the demand for organic produce will continue to increase, putting upward pressure on prices. An increase in supply will counteract those pressures. To what extent, and at which time, is difficult to predict in this market which is only just developing.

3.5.6 Gross margins and net margins

Most of the studies discussed in connection with the physical aspects of sustainable farming included a section on simple financial analysis of the data. These studies include Murphy (1975), Klepper et al. (1977), Cleveringa (1978), and Vine and Bateman (1981), and Lockeretz (1981). Details can be found in Appendix 3. Data are shown for variable costs, gross margins (produce times price minus variable cost) and net margins (gross margin minus fixed costs).

In general, variable costs are considerably lower on sustainable farms than on conventional farms.

Gross and net margins vary somewhat. Gross margins per hectare on sustainable farms as compared to conventional farms were lower in one study (Cleveringa 1978) and similar or higher in two studies (Murphy 1975; Klepper et al. 1977). In Vine and Bateman (1981) relative gross margins differed between enterprises. Klepper et al. (1977) also found that the type of enterprise could be important.

Net margins varied most. In two studies it was found that net financial returns under the two systems were similar (Murphy 1975; Cleveringa 1978). Cleveringa found that the net margin of the sustainable farm compared favourably with the average conventional farm, but unfavourably with those farms where good management was assumed. Klepper et al. (1977) found similar net margins on a farm basis, and Vine and Bateman (1981) found in general lower net margins on a farm basis on sustainable farms than on conventional farms, especially for the livestock enterprise.

In summary, information gathered from studies overseas indicates that the net financial benefits to the farmer in sustainable agriculture can be comparable to those in conventional agriculture.

3.6 Concluding Remarks

Results from the studies under review were varied, both for the physical and private financial aspects of farming. However, it was established that financial results on sustainable farms can be comparable to those on conventional farms. These results were obtained despite the fact that product quality, an aspect usually considered a point in favour of sustainable produce, was not taken into account in these comparisons. It was also despite the fact that inputs used in sustainable agriculture were researched less in the past than those used in conventional agriculture.

The surveys considered in this chapter were mainly from overseas. How is the situation in Australia? That is the topic of Chapter 5. But first a synthesis is provided in the next chapter of the main points made in this and the previous chapter by considering the effects of a partial movement from conventional to sustainable farming.

4 FROM CONVENTIONAL TO SUSTAINABLE FARMING: A SYNTHESIS[6]

4.1 Introduction

In order to obtain some idea about the costs and benefits of conventional farming as compared to sustainable farming the effects of a partial movement from conventional to sustainable agriculture are considered in this chapter.

A movement towards sustainable farming is expected to involve private and external benefits and costs. Together these comprise social benefits and costs. They are summarised under those headings in Table 4.1. 'Private' benefits or costs are defined as those initially accruing to, or borne by, those farmers - or their families - who adopt sustainable farming. Ultimately these benefits and costs, or parts of them, may be passed on to others through changes in market prices. External benefits and costs include conventional externalities experienced by other firms and individuals when a farmer shifts from conventional to sustainable farming. With the definitions used here, changes which a movement to sustainable farming causes in government payments/receipts for inputs or outputs subject to policy-induced distortions also represent externalities. Examples are fertiliser subsidies and subsidised medical services. This approach to defining externalities more broadly than is usually done (but see Buchanan and Stubblebine 1962, p.381; Baumol and Oates 1988, pp.16-17) is reasonable in the context and saves words.

When discussing the costs and benefits of an action, one of the decisions to make is whom to include in the calculations. The approach taken is the commonly used one of including all benefits and costs accruing to the nation, and ignoring benefits and costs experienced outside Australia. See Mishan (1982, pp.74-5) for support of this approach. No attempt is made to quantify the benefits and costs here.

4.2 Costs and Benefits

Increased supplies of organic produce (Table 4.1, item A.1) can be viewed as a clearcut private benefit only if marketing arrangements exist

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[6] This chapter is part of a paper by Wynen and Edwards (1988).

allowing such produce to be distinguished from the products of conventional farming. Because smaller volumes of organic produce would be expected, at least for a considerable time, and because of the cost of ensuring that products presented as organic are so, marketing costs will be higher for these products than for the products of conventional agriculture. This difference in marketing costs for the two classes of products is relevant in examining substitution of sustainable for conventional farming, and needs to be included in item B.2. The decreased availability of some products of conventional farming (item B.1) is a private cost in the case of such a substitution.

External benefits accrue from a decrease in the use of inputs which cause external costs, such as fertilisers and pesticides (item A.2). When a subsidy applies to the input (as for fertilisers until July 1988) a decrease in the subsidised input causes an external benefit to the taxpayer. When there is a tax on the importation or sale of an input, a decrease in its use generates an external cost to taxpayers. Sustainable farmers replace synthetic fertilisers and pesticides with other inputs (for example, rock dust and pheromones) or technologies (for example incorporation of green manure in the rotation; provision of right habitat for pest predators). An increase in the use of those resources should be on the debit side of a move towards sustainable farming (item B.3).

Pests are less likely to adapt to pest management measures in the sustainable than in the conventional sector (item A.3) for several reasons. These include the emphasis on prevention of occurrence of pests (as opposed to the treatment of the pest when it occurs), and a greater diversity of techniques in sustainable farming (for example use of crop rotations, trap crops, mechanical cultivation, and manipulation of planting dates) (see Section 3.3).

Improvements in the health of farmers and their families (item A.4) generate external benefits, as well as private ones, because users of medical services typically pay less than the social costs of providing them (for example, see Clements 1983). A decrease in health problems for farm neighbours and consumers are external benefits.

Improvement of soil quality (item A.5) occurs on the farm (see, for example, Arden-Clarke and Hodges 1988 and Section 5.4.1.8), with external benefits. Those are due to, for example, a reduction in costs of restoring damage caused by erosion, and nuisance caused by dust storms to people.

Table 4.1: Benefits and costs of a movement from conventional to sustainable farming

Item	Private	External
A. Benefits		
1. Increased availability of some products - e.g. organic cereals	*	
2. Decreased use of some inputs - e.g synth. fertilisers, pesticides	*	
3. Reduced risk of pest adaptation to farm management techniques	*	*
4. Improved human health		
- farmer and farmer's family (due to, e.g., reduced handling of pesticides)	*	*
- farmer's neighbours (due to, e.g., reduced exposure to spray drift)		*
- consumers (due to, e.g., reduced exposure to pesticide allergens		*
5. Improved soil quality		
- on-farm - e.g. improved soil struct.	*	
- off-farm - e.g. decreased erosion		*
6. Improved water quality	*	*
7. Reduced susceptibility to harsh seasons	*	
8. Reduced potential loss from rejection of exports of conventional products	*	
9. Increased personal satisfaction - e.g. due to provision of 'clean' food	*	
10. Decreased need for research related to conventional farming technologies	*	*
B. Costs		
1. Decreased availability of some products of conventional farming	*	
2. Establishment and operation of a marketing system for organic products	*	
3. Increased use of resources that substitute for synthetic fertilisers and pesticides - e.g. green manures	*	
4. Increased uncertainty about farming - e.g. due to more limited knowledge of technologies	*	
5. Decreased personal satisfaction - e.g. due to social pressures	*	
6. Increased need for research related to sustainable farming	*	*

Organic food (item A.1) and improved water quality (item A.6) are valued partly for their contribution to improving human health (because of the absence of chemicals and, for food, because of other qualities such as nutritional benefits). That is, the demand for organic food and for better water is partly derived from the demand for improved health. It is inappropriate to double-count. However, food grown on sustainable farms and cleaner water are also valued for other reasons - for example, perceived superior taste.Reduced susceptibility of farming to harsh seasons with sustainable farming (item A.7) is attributable to two factors. First, as cash costs in sustainable farming are generally lower than in conventional farming (see Sections 3.5.6 and 5.4.3), cash losses will be lower in climatically adverse years. The second factor is less obvious. Soils on sustainable farms are sometimes less susceptible to dry conditions (possibly due to relatively high organic matter content), with consequences for yields (Klepper et al. 1977). In dry years crops on sustainable farms suffer from drought-stress later than on conventional farms. In years of extreme drought this may not help (see Section 6.2.3).

Loss from rejection of exports (item A.8) occurs when levels of pesticide residue are detected in the produce which are unacceptable to the importing country.

Changes in personal satisfaction or psychic income resulting from a switch to sustainable farming reflect a range of personal and social factors specific to each individual or family. It can be expected that the net effect of these would be positive for some farmers (item A.9) and negative for others (item B.5). As in other contexts, estimation of these items ex-ante would be exceedingly difficult. However, since they involve private effects, it can be expected that individuals will allow appropriately for them in making decisions on type of farming.

Since the size of an industry or sector is a key determinant of the national benefit from research (Edwards and Freebairn 1981), reduction in the size of the conventional farming sector would cause a fall in the nationally-optimal research effort for this sector[7]. (The relevant measure

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[7] If there is underallocation of resources to agricultural research, as is widely accepted to be the case (for example, Ruttan 1982), it may be efficient for actual research for conventional agriculture to increase, even if this sector becomes smaller. But holding research policy constant, a fall in research into conventional agriculture would follow a fall in

of the decrease in size of conventional farming is not the change in absolute size, but the decrease compared with its size in the absence of the movement to sustainable farming). A reduction in allocation of resources to research into conventional farming (item A.10) is treated partly as a private benefit because farmers undertake some experimentation directly and because the cost of some research, mainly in the private sector, is paid for by farmers in input prices. Savings in the bigger (in Australia) public sector contribution to agricultural research would, with the taxonomy used, be an external benefit of a shift towards sustainable agriculture.

The last cost to be discussed, increased uncertainty about farming (item B.4) is, like decreased personal satisfaction (item B.5) to a lesser extent, a cost which is not intrinsic to sustainable farming. The degree of the cost is dependent on outside factors. In the case of uncertainty about farming, the cost is partly a function of the number of people who practise sustainable agriculture. It will automatically decrease with increasing numbers of practitioners of sustainable agriculture. Social pressure, leading to decreased personal satisfaction from farming, is to a large degree influenced by what is acceptable at that time. If sustainable agriculture loses the stigma which was attached to it in the past, this cost of transition from conventional to sustainable farming will automatically be reduced.

4.3 Concluding Remarks

At least two interesting points emerge from Table 4.1. The first is that a large number of items need to be considered in a complete benefit-cost analysis of a shift towards sustainable farming. These relate to changes not only in outputs and inputs, but also in resource quality, risk, personal satisfaction and research.

The second point concerns the relationship between the private and external impacts of a movement towards sustainable farming. On the costs side, if policy-induced distortions are absent, all impacts other than a

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size of this sector. If, on the other hand, the real research effort for conventional agriculture were held constant with a movement towards sustainable farming, thiscould make research closer to its nationally-optimal level, enhancing the attractiveness of the movement in benefit-cost terms.

component of research into sustainable farming can reasonably be viewed as private costs.[8] The fact that mainly private costs are involved makes estimation of the magnitudes easier.

On the benefits side, however, Table 4.1 has ten entries for private benefits and eight for external ones. This suggests that valuation problems are likely to be greater for benefits than for costs - a situation common in benefit-cost assessments. It points also to the likelihood that not all benefits are taken into consideration when decisions are made regarding the adoption of sustainable farming. This raises questions about the desirability of government intervention, which is taken up in Chapter 9.

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[8] The absence of policy-caused divergences is probably most questionable in relation to the reduction in output of conventional farming (item B.1).

5 SUSTAINABLE AND CONVENTIONAL AGRICULTURE IN SOUTH-EASTERN AUSTRALIA: A COMPARISON[9]

5.1 Introduction

Overseas studies showed that sustainable farming can be as financially rewarding as conventional farming (see Chapter 3). Does this apply under Australian conditions, where many soils have a low fertility status, while summers can be hot and dry?

Conacher and Conacher (1982) carried out a qualitative survey into organic farming in Australia. To enable a quantitative comparison of sustainable and conventional farmers it was essential to conduct a survey of sustainable farmers and of conventional counterparts. In this chapter such general information about the survey as the method of determining the sample, participants, the questionnaire, the methodology and the hypotheses, is supplied together with the analysis.

5.2 Preliminary Survey

In an attempt to obtain an extensive list of sustainable farmers, a preliminary survey was conducted. The geographical area concentrated upon was south-eastern Australia including Queensland, New South Wales, Australian Capital Territory, Victoria, South Australia and Tasmania. In November 1984 the first questionnaires were sent to farmers who were known, or thought, to be sustainable farmers. The questions were aimed at gaining knowledge about:

- farmer's opinion of the degree of sustainability of the production process
- enterprises in which the farmer was engaged
- size of enterprises
- relative importance of farm activities to total income
- farmer's willingness to participate in a follow-up survey
- names of other sustainable farmers

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[9] An earlier draft of this chapter was published as Wynen (1988a). Summaries were published in Wynen (1987) and Wynen (1989a).

In a covering letter the purpose of the questionnaire was explained, and the different questions discussed (Appendix 4).

Names of sustainable farmers were obtained in many ways. At organic conferences and festivals participants were made aware of the intended research, and asked to come forward if they wanted to participate or if they knew people who might be interested. Letters were written to the editors of all major rural papers in south-eastern Australia, and to organic farming and gardening organisations. Retailers of sustainable produce were approached for names of commercial suppliers. Farmers listed in Conacher and Conacher (1982) or in the Willing Workers on Organic Farms program, if appearing to be commercial, were sent a letter. As mentioned, on the survey schedule itself a question was asked about names of other sustainable farmers.

Table 5.1: Number of replies to preliminary questionnaire by income derived from farming and degree of sustainability

Enterprise	1	2	3
Cereal/livestock	26	26	21
Mainly grazing	43	30	27
Dairy	15	15	15
Mixed cropping	11	9	9
Tree crops: fruit, nuts, other	39	19	16
Vegetables	11	6	5
Mixed fruit/vegetables herbs/flowers	34	10	10
Small scale mixed crop/livestock	11	0	0
TOTAL	**190**	**115**	**103**

1 = Total number of answers

2 = Farmers deriving more than 49 per cent of their income from farming

3 = Farmers deriving more than 49 per cent of their income from farming, and who classified themselves as sustainable producers

In total, 281 questionnaires were dispatched of which, after one reminder to non-responders, 190 were returned by the addressee (Table 5.1, column 1). Of these 190 answers, 115 were from producers who derived 50 per cent or more of their income from farming (Table 5.1, column 2).

To ascertain the degree of sustainable farming practised (as defined by the US Department of Agriculture 1980), farmers were asked to rate themselves on a scale from one to six, one being fully sustainable, and six being fully conventional. Of the 115 producers who derived half or more of their income from farming, 12 rated themselves four to six on this scale. Those who classified themselves one to three are included in column 3 of Table 5.1. The main interest of this table is that all major enterprises in Australia are represented by sustainable growers.

Table 5.2: Comparison of distribution of sustainable and conventional farms according to enterprise

Enterprise	1	2
Cereal/livestock and mixed cropping	29	27
Mainly grazing	26	45
Dairy	15	13
Horticulture	30	15

1 = Percentage of sustainable farmers (derived from Table 5.1, 3)

2 = Percentage of conventional enterprises in 1983-84 (derived from ABS 1988), excluding poultry, pigs, sugar cane, peanuts, tobacco and cotton.

Comparing the distribution of sustainable (Table 5.2, column 1) and conventional (Table 5.2, column 2) farming enterprises in south-eastern Australia, a lower proportion of sustainable farms are drawn from the grazing industry and more from horticulture than in the total farming community as shown by the Australian Bureau of Statistics (ABS) (1988). Synthetic fertilisers and pesticides are used most intensively in horticulture, making it likely that negative effects (for example on human health) are experienced most severely in this enterprise. It is therefore possibly not surprising that the percentage of horticulturalists practising sustainable agriculture is relatively high.

Although many farmers indicated that they were not able or willing to supply names of other farmers, by far the majority of new names was acquired in this way. Since, after two years, no new names appeared via this source, it was assumed that most of the sustainable farmers in south-eastern Australia at that time had been identified.

5.3 Main Survey

5.3.1 Participants

As some aspects of farming (such as relative input use, output, and output prices) may differ considerably between enterprises, the decision was made to concentrate on one agricultural industry. The cereal/livestock industry was chosen for several reasons. The first reason for the choice was the desirability to study a cropping enterprise, because it is in cropping that differences between the sustainable and conventional systems are most pronounced. These differences exist both in use of inputs, and in the effect on the long-term productivity of the farm, through the system's effect on the soil. The second reason for choosing the cereal/livestock industry was that this is a major agricultural industry in Australia.

Of the 35 producers who indicated that they were engaged in broadacre cropping (26 cereal livestock and 9 mixed cropping) and who derived over 49 per cent of their income from farming, 18 were interviewed. Farmers not interviewed included those who, judged by their own classification or by a pre-interview telephone conversation, were considered to be not sufficiently sustainable (7) or, on closer inspection, were engaged mainly in non-cropping or non-broadacre farming activities (5). Other reasons for exclusion were sale of the farm before the interview could take place (3), and use of irrigation (1), while 1 farmer declined to be interviewed. During the survey 3 more names came to the attention of the interviewer, and 1 producer, who had not answered the preliminary questionnaire, agreed to be included. In total 22 farmers were interviewed. Of those 22, 2 concentrated on livestock (although some crop was grown) and 20 fell in the category of broadacre, dryland crop producers.

Before the main survey was carried out a pilot survey was conducted. As the total number of farmers that could be included in the survey was rather small, it was decided to interview only three farmers in the pilot survey. Two of these were unlikely to be suitable for inclusion in the analysis due to the degree of sustainable management and to the use of irrigation. The third producer was interviewed because of proximity to the first two. A conventional counterpart farmer of the third grower in the pilot survey was also included (for the choice of a farmer counterpart: see below). This pilot survey took place in April 1986 for the cropping year 1984-85.

After adjustments were made to the questionnaire, the main survey was carried out in October 1986 (Queensland and New South Wales), and in February 1987 (Victoria and South Australia). Before the visit farmers were sent written notification, which was followed by a telephone call to ensure that both the visit, and timing, were acceptable.

Of the 20 farmers interviewed, 9 were judged to be fully sustainable, and 5 semi-sustainable; the rest farmed in such a way that differentiation from the conventional system was not warranted. The high percentage of interviewed farmers that had to be discarded for the purposes of this study reflects the fact that a telephone conversation was not always sufficient to ascertain the extent of adherence to sustainable practices. In addition, when their suitability was in doubt, farmers were generally interviewed on the grounds that there was a chance that they could be included. When, as in this case, the sample is very limited, the penalty for discarding wrongly is considerable.

The first criterion for the inclusion of farmers in the 'fully sustainable' category was that no synthetic fertilisers or pesticides prohibited in the Standards for Organic Products, issued by the National Association for Sustainable Agriculture (undated) (NASAA), were used in cropping (for exceptions and reasons for them see Appendix 5). Apart from the absence of these inputs, there had to be clear indications of the use of other techniques in the management system, in order to deal with soil fertility and pest problems. Such techniques include, for example, the use of green manure in the cropping program; a crop rotation which allows build-up of organic matter in the soil; and use of livestock and farm equipment for weed management. In order to be included farmers had to have practised sustainable agriculture for at least five years. The reason is that, in the first years after transition, biological imbalances in the soil and lack of experience of the system (see Lampkin 1986b) can distort the comparison. For this reason one of the nine fully sustainable growers, who had farmed sustainably for one year previous to 1985-86, was excluded from the analysis.

The sustainable farmers interviewed were compared with conventional farmers whose farms were near those of the sustainable farmers, and who were broadacre cereal growers. To find an appropriate comparison, local officers of the Department of Agriculture were asked to nominate a conventional farmer who, in their opinion, was at least as good a manager as the sustainable farmer.

Other factors by which the conventional farmer was chosen were similarity of soil type, local climate, and farm size. Additional factors can also influence the profitability of a farm. For example, the degree of indebtedness and the point in the farmer's lifecycle affect the need for cash at a particular time, and hence decisions regarding cropping and stocking rate. As these factors were usually not known before the interview, they could not be taken into consideration when deciding on the comparison. However, demographic factors such as age and education turned out to be fairly similar for the two groups of farmers (see Section 5.5). Where possible, the sustainable farmers were asked for their opinion about the choice of counterpart conventional farmers, and their comments were taken into account.

As it was very difficult to find conventional farmers who were good managers, and whose farms were similar in all the other aspects (soil type, climate and size), farm size was usually the first criterion to be dropped. It is for this reason that comparisons on a total farm basis would be rather meaningless, and that per hectare data are presented.

For reasons of confidentiality the precise location of the farmers included in the survey can not be divulged. However, all growers are located in the wheat/sheep zone (as defined by the then Bureau of Agricultural Economics (BAE) (1987a, p.30)). Some general characteristics of the land are included in Section 5.4.1.8.

The interviews were all carried out on the farm by the same interviewer (the author), and generally lasted between three and six hours.

5.3.2 Questionnaire

The main part of the questionnaire consisted of questions asked by the BAE (1985a) in its regular broadacre industry farm survey. This was supplemented with questions considered important in the context of the present research. These covered areas such as:

- use of pesticides and fertilisers
- timing of activities related to cropping
- qualitative data on yields and labour needs, especially in the period converting to sustainable farming
- motives for farming in general and for farming in a sustainable way in particular
- information sources on sustainable agriculture
- managerial indicators
- perceptions of risk attached to sustainable farming

The decision to include these questions was based on research carried out by others in this connection, including Klepper et al. (1977), Conacher and Conacher (1982), and Vine and Bateman (1982).

5.3.3 Methodology

Tests were carried out to investigate the differences between sustainable and conventional farming for a number of variables. As the conventional farmers were chosen on the basis of similarity to sustainable farmers in terms of certain characteristics (such as climate and soil type), the tests used are those appropriate for 'paired samples' (Ryan, Joiner and Ryan 1985, pp.101-105).

In total, three groups were identified for comparison. The first was the group of fully sustainable farmers (8), the second the semi-sustainable farmers (5), and the third group was of all sustainable farmers combined (13). The differentiation between the first two groups was made on the basis of differences in degree of adoption of the sustainable system, that is, in the degree of use of certain inputs and adoption of certain practices. The reasons for differentiation are twofold.

1. It is expected that differences between the fully sustainable farmers and their conventional counterparts in variables which are not used in the selection (such as yield and financial returns to farming) might be easier to detect than those between the semi-sustainable farmers and their conventional counterparts.
2. Differences between the two groups of sustainable farmers can be analysed. This might lead to a better insight into the problems and possibilities of sustainable farming.

There are disadvantages associated with statistical analysis involving such small samples, a major one being that the tests are not very powerful. This is because in such an analysis the Type II error, of accepting the hypothesis as true while it is false, can be relatively high. This means that with small samples it is difficult to establish a statistically significant difference. In order to alleviate this problem the third group was made up consisting of all sustainable farmers. This approach was adopted despite the fact that it was recognised that for certain variables the effect of one category of sustainable producers might be masked by those of the other category.

A second disadvantage arises in working with small samples if a normal distribution of the differences cannot be assumed a priori. Although testing for normality is possible, reliability decreases with sample size. It was therefore decided not to use the Student-t test, for which a normal distribution is needed. To test for differences between a group of sustainable and of conventional farmers, the paired Wilcoxon test was used. Differences between two groups of sustainable, or two groups of conventional farmers were tested with the Mann-Whitney test. These non-parametric tests (that is, tests for which no assumptions of normality are made) may be marginally less powerful than a Student-t test if the underlying distribution is normal.

For the Wilcoxon test the values in the sample of conventional farms are deducted from those of the sustainable farms. The resulting series is first converted to absolute values, after which the non-zero values are ranked. Subsequently, the rank numbers corresponding to the originally negative values are added, which gives W. The null-hypothesis to be tested is that the actual W is similar to the expected W when there is no difference with a mean of n(n+1)/4, and a variance of n(n+1)(2n+1)/24, where n is the number of observations in the sample (Ryan, Joiner and Ryan 1985, pp.287-8).

Details of expenditure on fertiliser per hectare cropped are used to illustrate the case. Values for this input for the sustainable and conventional farmers individually are as follows:

Pair	1	2	3	4	5	6	7	8
Sustainable farmers	27	43	0	0	0	0	0	0
Conventional farmers	42	23	34	42	33	14	0	27
Difference	-15	20	-34	-42	-33	-14	0	-27
Absolute difference	15	20	34	42	33	14	0	27
Rank	3	1	6	7	5	2		4

Actual W = 3+6+7+5+2+4 = 27

Expected W = 7(7+1)/4 = 14

Variance of expected W = 7(7+1)(2x7+1)/24 = 35

Standard deviation of expected W = 35 = 5.9

The p-values in the tables in Section 5.4 indicate the level of confidence with which the null-hypothesis (that expenditure for fertilisers per hectare cropped on conventional farms is equal to that on sustainable farms (see Section 5.3.4)) can be accepted. For example, if the p-value for fertiliser used per hectare cropped equals 0.038 (Table 5.3), the probability is 3.8 per cent that these data occur if the null-hypothesis were true. In other words it is very likely that a difference does exist between the fertiliser use of the two types of farming. The null-hypothesis can be rejected at the 96.2 per cent level of confidence. This means that there is a 3.8 per cent chance that a Type I error, of incorrectly rejecting the null-hypothesis, is made.

The p-values in the tables are the individual p-values for the variables. As many comparisons are made in this analysis, it could be argued that tests for multiple comparisons should be carried out (see Devore and Peck 1986). However, as the returns to farming is the main characteristic to be explored, with the other measures being analysed to get an indication of differences between the sustainable and conventional management system, multiple testing has not been performed here.

Because the samples are small, extra care was taken to ensure that results were not due to outliers. Every variable which showed a statistically significant difference was checked with the Sign-test, a less assuming (about the symmetry of the population) and less powerful test than the Wilcoxon test (Ryan, Joiner and Ryan 1985, p.277-86). A divergence of the results of these two tests would indicate the need for further investigation of the variable. In no case was this need established.

A Mann-Whitney test is similar to the Wilcoxon test in that it is also a non-parametric test. It is used for the analysis of un-paired data. For the test the individual values in the two samples are combined into one sample and ranked. The actual W is calculated by summing the rank numbers of the data of one of the samples. Analogous to the Wilcoxon test, the p-values indicate the likelihood of these two samples being derived from the same population.

In cases where no assumptions can be made a priori regarding the direction of the difference between the two systems (for example wheat yields) a two-tailed test is appropriate (see Freund 1974, p.272). Where there is a basis for assuming that the value of the sample is either larger (for example returns per tonne of wheat) or smaller (for example use of pesticides) than that of the comparison, a one-tailed test may be used. In such a case the p-value is half of that calculated in a two-tailed test. The hypotheses for the different variables are set out in Section 5.3.4. The p-values in the tables in Section 5.4 are those appropriate for the hypotheses for which they are calculated.

Inputs used have been quantified by expenditure on these inputs. The use of a common unit of measurement enables an easy comparison between the two systems. With an homogeneous input (such as fuel), and assuming that prices for two farmers in one locality are similar, expenditures give as accurate an indication of relative input use in the two systems as physical quantities. However, with inputs such as fertilisers and pesticides, many different substances can be used, and expenditure might therefore not give a perfect indication of relative use. But, as it is likely that two farmers in one locality have the same kind of nutrient deficiencies and pest problems, it is also likely that the same kind of fertilisers and pesticides would be used, if used at all.

In cases where values needed to be imputed, care was taken not to advantage sustainable farmers (for examples see Appendix 5).

Averages shown in the tables in Section 5.4 are unweighted averages, that is, not weighted by the farm area. The reason for using unweighted rather than weighted averages is that the farms were located in widely different areas with widely different input needs and output potential. All farms were broadacre farms, and on average area operated was similar on the sustainable and conventional farms (see Table 5.14), but not always equal for two farms of one pair. Weighted averages (for example yield weighted according to cropped area) bias the results towards the larger farm, while no extra information is gained from such a calculation. The following example illustrates the point.

Case 1:

	Yield	Area Cropped	Production	Yield Weighted Average
	t/ha	ha	t	t/ha
Sustainable farmer 1	2.0	100	200	
Sustainable farmer 2	4.0	100	400	
Total		200	600	3.0
Conventional farmer 1	2.0	100	200	
Conventional farmer 2	4.0	100	400	
Total		200	600	3.0

Case 2:

	Yield	Area Cropped	Production	Yield Weighted Average
	t/ha	ha	t	t/ha
Sustainable farmer 1	2.0	100	200	
Sustainable farmer 2	4.0	100	400	
Total		200	600	3.0
Conventional farmer 1	2.0	200	400	
Conventional farmer 2	4.0	100	400	
Total		300	800	2.7

In the first case the two farmers of each pair crop equal areas, and obtain the same yield per hectare cropped. This results in an unweighted ((2.0 + 4.0) / 2) and a weighted ((2.0 x 100 + 4.0 x 100) /200) average of 3.0 tonne per hectare. In the second case the only difference is that the conventional farmer 1 crops twice the area of that in case 1. Yields for all farmers stay the same as in case 1. The unweighted average stays at 3.0 tonnes per hectare, while the weighted average becomes 2.7 tonnes per hectare for the conventional farm, only because one of the conventional farmers happens to grow more wheat.

Further, as farm size was the aspect to which least attention was paid when selecting the counterpart conventional farmer, it is inappropriate to weight the variable by cropped area.

The same reasoning is valid for the exclusion of both of a pair of farmers if figures for only one of the pair are available. For example, where one conventional farmer did not grow wheat, the figures of the sustainable farmer were also excluded in the calculation for the average of the sustainable farmers. Since this farmer lived in an area with a high yield potential, the average of the wheat yield for the eight sustainable farmers would be inappropriately high as compared to the average of the seven conventional farmers.

In many studies 'gross margin analysis' is used to study different farm enterprises (see, for example, Barnard and Nix (1979)). With such an analysis, variable costs are deducted from returns, to indicate the viability of the different enterprises. In the present study the analysis closely follows that used by the Australian Bureau of Agricultural and Resource Economics (ABARE). The measures used give results close to those of a gross margin analysis for a whole farm. However, items included for the calculations of the cash operating surplus are not identical to those included in a gross margin. A summary of included items in the different categories discussed in this paper is provided in Appendix 6. Apart from ease of use of the measures due to available documentation, ready comparison with Australian farmers covered by the ABARE survey is also an advantage (BAE 1987a). The procedure is explained in the text.

For most inputs expenditure is calculated per hectare cropped and per hectare operated. The first figure gives an indication of differences of practices, while the expenditure per hectare operated is a component of the end result, the returns to farming.

5.3.4 Hypotheses

The hypotheses are listed according to whether the variable is expected to be higher or lower for sustainable farmers than for their conventional counterparts (in which case a one-tailed test is used), or whether it is expected to be similar for the two types of farming (two-tailed test). Expectations are based on choice of sample (for example, for fertiliser and pesticide use the sustainable farmers were chosen on the basis of limited use of these inputs, so that a one-tailed test is the obvious choice), or on literature on the topic. Where one-tailed tests are used, the reasons are discussed under the different variables in Section 5.3.

In some cases expectations differed for the three groups of sustainable farmers, the fully sustainable (fs), the semi-sustainable (ss) and all sustainable farmers (saf). In these cases, specific mention is made of the particular group for which the hypothesis is posed.

5.3.4.1 One-tailed test

- Variables, for which the sustainable farmers are expected to have higher averages than the conventional farmers:
  1. Number of crops grown per farm
  2. Receipt per tonne of wheat (fs)
  3. Receipt per hectare of wheat (fs)
  4. Wheat receipts as a percentage of total crop receipts (fs)
  5. Receipts per hectare of non-wheat crops (fs)

- Variables, for which the sustainable farmers are expected to have lower averages than the conventional farmers:
  1. Expenditure on fertilisers, per hectare cropped and operated
  2. Expenditure on pesticides
     - on crop per hectare cropped
     - per unit of stock
     - total per hectare cropped and operated
  3. Cropped area: . total
     . as a percentage of arable area
  4. Wheat area as a percentage of total area cropped
  5. Wheat receipts as a percentage of total crop receipts (ss)
  6. Total cash costs per hectare operated

5.3.4.2 Two-tailed test

- Variables, for which sustainable farmers are expected to have averages similar to those of conventional farmers:
  1. Expenditure on interest
  2. Expenditure on fuel, per hectare cropped and operated
  3. Depreciation of machinery and equipment, per hectare cropped and operated
  4. Age and size of largest tractor
  5. Expenditure on labour per hectare operated
  6. Area operated
  7. Unimproved capital value per hectare operated
  8. Improved capital value per hectare operated
  9. Arable area
  10. Arable area as a percentage of total area operated
  11. Wheat yields
  12. Receipts per tonne of wheat (ss, saf)
  13. Receipts per hectare of wheat (ss, saf)
  14. Wheat receipts as percentage of total crop receipts (saf)
  15. Receipts per hectare of non-wheat crops (ss, saf)
  16. Financial receipts from all crops per hectare cropped and operated
  17. Livestock carrying rates
  18. Wool yield per hectare operated
  19. Financial receipts from stock per hectare grazed and operated
  20. Total cash receipts per hectare operated
  21. Total farm cash operating surplus per hectare operated
  22. Returns to capital and management per hectare operated
  23. Return to capital and management per dollars of capital invested
  24. Adjusted returns to capital and management per hectare operated (with actual and conventional wheat prices)
  25. Adjusted return to capital and management per dollars of capital invested (with actual and conventional wheat prices)
  26. Farmer's age
  27. Number of years farmed: in total and on the present property

5.4 Analysis of Inputs and Outputs

In this section the quantitative variables derived from the survey are discussed. The use of inputs (Section 5.4.1), together with outputs and output prices (Section 5.4.2) leads to the returns to farming (Section 5.4.3). Psychic income is discussed in Section 5.4.4.

The data relate to three groups of sustainable farmers and their conventional counterparts. The abbreviations used for these groups are fs and cfs (fully sustainable and conventional fully sustainable), ss and cfs (semi-sustainable and conventional semi-sustainable) and saf and caf (sustainable all farms and conventional all farms).

5.4.1 Inputs

5.4.1.1 Fertilisers

In sustainable agriculture, as defined by NASAA (1986), synthetic fertilisers are specifically named as inputs which are used not at all, or sparingly, in the production process. However, according to the Australian Organic Standards (NASAA undated), ground rocks and some other compounds are allowed in sustainable agriculture.

Because it was expected that some sustainable farmers would use no fertiliser, so that expenditure by them on this input would be lower than for conventional farmers, a one-tailed test was considered appropriate.

Expenditure on fertilisers is shown in Table 5.3. Of the eight fs farmers included, six did not use any fertilisers. On the two farms where (allowed) fertilisers were used, the amounts spent were $27 and $43 per hectare cropped compared to $42 and $23 on the counterpart conventional farms. Of the eight conventional farmers paired with the fs farmers (cfs), one did not use fertilisers. In the particular area where this farmer operated, fertilisers had not been used extensively in conventional cereal growing in the past. At the time of the interview, however, many farmers were starting to use this input, and the interviewed farmer said that he was also considering fertiliser use in the future. The average values of fertiliser per hectare cropped (including farms where no fertiliser was used) were $9 and $27, and per hectare operated $3 and $19, for the groups of eight fs and cfs farmers respectively.

Table 5.3: Fertiliser expenditure

	Cropped Area		Operated Area	
	$/ha	p-value	$/ha	p-value
Fully sustainable (fs)	8.8		3.0	
Conventional (cfs)	26.9		19.1	
Difference [8]	**-18.1**	**0.038 ****	**-16.1**	**0.018 ****
Semi-sustainable (ss)	20.3		6.2	
Conventional (css)	21.8		9.6	
Difference [5]	**- 1.5**	**0.295**	**- 3.4**	**0.030 ****
Sust. all farm. (saf)	13.2		4.3	
Conv. all farm. (caf)	24.9		15.5	
Difference [13]	**-11.7**	**0.032 ****	**-11.2**	**0.002 *****

Significant levels of the paired Wilcoxon test
* = 90 per cent confidence level
** = 95 per cent confidence level
*** = 99 per cent confidence level
Figures, apart from the p-values, are group means.
Figures in []: number of farms included in the calculation of the mean.
Discrepancies in 'Difference' and the differences between the values in the table are due to rounding.

The ss farmers used more fertilisers per hectare cropped than the fs farmers. Some used fertilisers which are not allowed under the Organic Standards. One of the five used more than the conventional farmer counterpart. On average, the expenditure on fertilisers by the ss farmers was similar per cropped hectare to that of their counterpart conventional farmers (css). Per hectare operated, however, the ss farmers spent less (p = 0.030).

Thus, calculated for all farms, fertiliser expenses were lower for producers in the sustainable (saf) than for those in the conventional system (caf). On average, the cost of fertilisers per hectare cropped on sustainable farms was approximately half that on conventional farms ($p = 0.032$). If calculated on a per hectare operated basis conventional producers spent almost four times as much as sustainable farmers ($p = 0.002$). These findings are consistent with the expectations as described earlier in this section.

5.4.1.2 Feed

Since crops produced on mixed farms can be used as stock feed, lack of soil fertility can be compensated for by buying feed. On broadacre farms in Australia, however, little feed is generally purchased. Exceptions are in years of extreme conditions (such as drought). In the survey year very little feed was purchased.

Of the five pairs of fs and cfs farmers where both the sustainable and the conventional farmer kept stock, only one farmer in each group bought any feed. All ten of the ss and css farms carried stock. One of the ss farms was a sheep stud, where feed is more likely to be bought than on an average broadacre farm. Expenditure on feed on this farm accounted for over 40 per cent of the total for the group. On a second ss farm feed was bought exclusively for a few pigs. This accounted for 36 per cent of the average cost of feed on all ss farms. As feed was purchased on so few farms, or for such exceptional circumstances, it was considered inappropriate to carry out tests to determine differences between the two groups.

5.4.1.3 Pesticides

One of the criteria used to determine the appropriateness of including a producers in the category of sustainable farmers was the avoidance of pesticides at least in the cropping phase. Also in livestock the use of pesticides is assumed to be decreased as compared to in conventional agriculture. For this reason one-tailed tests were performed on the variables related to pesticide use.

Table 5.4: Expenditure on pesticides used in crops and on stock

	Crop		Stock		
	$/ha cropped	p-value	$/Unit	p-value	% of total
Fully sustainable (fs)	0.2		0.09		61
Conventional (cfs)	16.7		0.34		18
Difference [8,5,5]	**-16.5**	**0.007 *****	**-0.25**	**0.030 ****	**43**
Semi-sustainable (ss)	1.0		0.31		49
Conventional (css)	6.1		0.68		28
Difference [5,5,5]	**-5.1**	**0.030 ****	**-0.37**	**0.053 ***	**21**
Sust. all farmers (saf)	0.5		0.20		55
Conv. all farmers (caf)	12.6		0.51		23
Difference [13,10,10]	**-12.1**	**0.001 *****	**-0.31**	**0.006 *****	**32**

For symbol definition: see footnote Table 5.3

A large proportion of the total amount spent on pesticides used in conventional agriculture is used in cropping. The pesticides can be divided into categories according to use: those used on field crops include weedicides, fungicides, and insecticides; on stored crops mainly insecticides are used; and seed protectants include fungicides. Pesticides reported in Table 5.4 are those used on field crops and on stock. Averages for pesticides used on stock are calculated only for those pairs of farms on which stock was kept. The difference in expenditure on pesticides for crops between sustainable and conventional farmers is statistically significant for all groups of farmers (p = 0.001). The expenditure on pesticides by the fs farmers was mainly on insecticides allowed under the Standards for Organic Produce (NASAA undated).

On average over all farms, more than half of the money spent on (allowable and non-allowable) pesticides used by sustainable farmers was used in animal husbandry (not shown in a table). The amounts spent by all three groups of sustainable farmers per animal were significantly lower than those spent by conventional farmers (p = 0.006). The fs farmers paid approximately a quarter of the amount used per animal on conventional farms, while the comparable figure on the ss farms was below half that on the css farms.

Table 5.5: Total expenditure on pesticides used per area cropped and per area operated

		Cropped Area		Operated Area	
		$/ha	p-value	$/ha	p-value
Fully sustainable	(fs)	1.1		0.4	
Conventional	(cfs)	18.1		14.1	
Difference [8]		**-17.0**	**0.007 *****	**-13.7**	**0.007 *****
Semi-sustainable	(ss)	2.9		0.9	
Conventional	(css)	8.7		3.8	
Difference [5]		**-5.8**	**0.030 ****	**-2.9**	**0.030 ****
Sust. all farmers	(saf)	1.8		0.6	
Conv. all farmers	(caf)	14.5		10.1	
Difference [13]		**-12.7**	**0.001 *****	**-9.5**	**0.001 *****

For symbol definition: see footnote Table 5.3

The difference between the fs and cfs farmers in total pesticide use per hectare operated (Table 5.5) was much greater ($0.4 and $14.1 respectively) than that between the ss and css farmers ($0.9 and $3.8 respectively), both in relative and absolute terms. Expenditure on this input was significantly lower for the sustainable farmers in all three groups ($p < 0.05$). This is consistent with the requirements for inclusion of sustainable farmers in the survey as a sustainable farmer.

The css farmers spent, on average, less than half of the amount on pesticides for field crops that was spent on cfs farms ($6.1 and $16.7 respectively, see Table 5.4). This reflects the fact that the cfs farmers, and their sustainable counterparts, are located in more intensive crop growing areas than the css farmers, a point to be explored also in connection with other inputs and outputs.

5.4.1.4 Credit

No differences in interest paid by the practitioners of the two types of farming system were established ($p > 0.1$) (see Table 5.6).

Table 5.6: Interest paid per hectare operated

		$/ha	p-value
Fully sustainable	(fs)	5.0	
Conventional	(cfs)	16.2	
Difference [8]		**-11.2**	**0.363**
Semi-sustainable	(ss)	15.2	
Conventional	(css)	21.4	
Difference [5]		**-6.2**	**0.787**
Sust. all farmers	(saf)	8.9	
Con. all farmers	(caf)	18.2	
Difference [13]		**-9.3**	**0.328**

For symbol definition: see footnote Table 5.3

Debt is often related to the life cycle variable and, in the case of farmers, to the number of years established on the farm. These factors were very similar for the two types of farmers or, as the fully sustainable farmers had been on the present property shorter than the conventional farmer counterparts (see Section 5.5.2), were suggestive of relatively low debts for conventional farmers.

Tables 5.7 and 5.8 contain further details of interest paid. In Table 5.7 the pairs of farmers with low loans have been separated from those with loans higher than the limit set here ($5/ha). In addition, the pairs of farmers where one has loans of up to $5, and the other higher than this amount have been identified.

Table 5.7: Interest paid per hectare operated by pairs of farmers

	Conventional farmers	
	$5 and below	Over $5
Fully sustainable (fs)		
$5 and below	3	3
Over $5	1	1
Semi-sustainable (ss)		
$5 and below	1	2
Over $5	0	2
Sust. all farmers (saf)		
$5 and below	4	5
Over $5	1	3

Of the eight fs farmers, six (75 per cent) paid $5 or less per hectare operated, compared to four (50 per cent) of the cfs farmers. The comparable figures for the ss and css farmers are three (60 per cent) and one (20 percent), respectively.

In Table 5.8 figures are given for the number of farmers by 'purpose of loan'. Each farmer could have more than one loan, and only existing loans were included. Ideally, a similar table should have been presented as Table 5.7. However, as such a table would become rather large, the idea was abandoned.

Table 5.8: Numbers of sustainable and conventional farmers with present debts incurred for various purposes

	Purpose of loan					
	Land		Build. & Struc.	Veh. & Mach.	Work. Cap.	Other
	Purch.	Dev.	Dev.	Purch.		
Fully sustainable (fs)	2	2	0	0	3	1
Conventional (cfs)	3	1	0	1	4	0
Semi-sustainable (ss)	2	0	1	0	2	1
Conventional (css)	5	0	0	0	2	0
Sust. all farmers (saf)	4	2	1	0	5	2
Conv. all farmers (caf)	8	1	0	1	6	0

Build. & Struc. = Buildings and Structures
Veh. & Mach. = Vehicles and Machinery
Work. Cap. = Working Capital
Purch. = Purchase
Dev. = Development

The most striking difference between the two types of farming is in borrowing for the purpose of land purchase. Of the 13 conventional farmers 8 had borrowed to buy land, 5 of whom were css farmers (the total of that group). Of the sustainable farmers, 4 had borrowed for that purpose (2 of whom were ss farmers).

Of the total of 12 farmers who had borrowed for land purchase, 7 were ss or css farmers. This might indicate that the ss-css farmers were living in areas where expansion is more prominent than in the area where the fs-cfs producers live.

The sustainable farmers were asked whether, after changing from conventional to sustainable farming, any problems had been experienced with obtaining credit due to the production system used. Six farmers felt that this question was not relevant to them because they had never borrowed, or because they had always practised the sustainable system (that is, there had been no change in production system). The other seven farmers all reported that they had never had any problems in obtaining finance on account of their farming system.

5.4.1.5 Fuel

A large percentage of fuel used on mixed broadacre farms is used for cropping. Data have therefore been reported here on the basis of expenditure per hectare cropped, as well as per hectare operated.

It could be argued that more fuel is needed on sustainable farms where mechanical cultivation for weed control purposes is used as opposed to pesticide applications. In that case a one-tailed test should be used. However, the scant evidence available (see, for example, Vine and Bateman (1981, pp.114-116)) does not support this argument, so a two-tailed test was considered appropriate for the analysis.

For all three groups analysed, a similar amount of fuel per cropped hectare was used ($p > 0.1$) (see Table 5.9).

As the fs farmers cropped a lower percentage of their arable area than their conventional counterparts (see Section 5.4.1.8), comparative expenditure for fuel per hectare operated was different from that per hectare cropped. The fs farmers used approximately half that used by their conventional farmer counterparts ($p = 0.030$). Ss and css farmers spent similar amounts per hectare operated ($p = 0.590$). The average quantity of fuel used by all sustainable farmers combined was less than two-thirds that used by conventional farmers (p = 0.025).

Table 5.9: Expenditure on fuel

	Cropped Area		Operated Area	
	$/ha	p-value	$/ha	p-value
Fully sustainable (fs)	35.4		11.5	
Conventional (cfs)	33.1		21.4	
Difference [8]	**2.3**	**0.800**	**-9.9**	**0.030 ****
Semi-sustainable (ss)	23.1		7.1	
Conventional (css)	16.4		7.3	
Difference [5]	**6.7**	**0.178**	**-0.2**	**0.590**
Sust. all farmers (saf)	30.7		9.8	
Conv. all farmers (caf)	26.7		16.0	
Difference [13]	**4.0**	**0.255**	**-6.2**	**0.025 ****

For symbol definition: see footnote Table 5.3

5.4.1.6 Machinery and equipment

Machinery and equipment is an important input in crop production. Because in broadacre farming most machinery is used in cropping, costs associated with this input were calculated per cropped area as well as per hectare operated.

Depreciation costs per cropped area were similar for the two types of farming within all three groups (p > 0.1) (see Table 5.10).

As the fs farmers grew crops on a smaller percentage of their arable land than the conventional farmers (see Section 5.4.1.8), expenditure per area operated was lower on the fs than on the cfs farms (p = 0.080).

Table 5.10: Depreciation of machinery and equipment

	Cropped area		Operated area	
	$/ha	p-value	$/ha	p-value
Fully sustainable (fs)	89.0		31.3	
Conventional (cfs)	100.7		73.8	
Difference [8]	**-11.7**	**0.624**	**-42.5**	**0.080 ***
Semi-sustainable (ss)	49.6		16.7	
Conventional (css)	39.8		18.6	
Difference [5]	**9.8**	**0.418**	**-1.8**	**1.00**
Sust. all farmers (saf)	73.9		25.7	
Conv. all farmers (caf)	77.3		52.5	
Difference [13]	**-3.4**	**0.944**	**-26.9**	**0.069 ***

For symbol definition: see footnote Table 5.3

The use of machinery involves many aspects: efficiency in use (fuel consumption per unit of land); rate of use (largely dependent on available labour resources and spread of farm activities); risk of breakdown; and comfort (for example air-conditioned as opposed to open tractor cabins). As the difference in cost between the fs and cfs farmers is considerable (the highest single difference of input cost) it is worthwhile to look at this cost in more detail.

Since the fs farmers cropped less of their arable land than their conventional counterparts, the size of their machinery and equipment can be relatively small without repercussions in terms of timeliness of operations. On the other hand, there are reasons to believe that timeliness is more crucial on sustainable farms than on conventional farms. This is due to the fact that in sustainable agriculture no pesticides (for example weedicides) can be used as a back-up if operations are delayed beyond the optimal time. To which extent the forces offset one another depends on, for example, the degree of difference in area cropped, decrease in yield by non-timeliness, and the degree of uncertainty about the weather.

Another factor of importance for the relatively low depreciation costs on sustainable farms could be the age of machinery. With relatively small areas in a particular crop, penalties for breakdowns are less severe than on farms with only one crop. This means that the risk factor on diversified farms is lower than on those where monocropping occurs.

Table 5.11: Size and age of biggest tractor

	Size		Age	
	Hp	p-value	Years	p-value
Fully sustainable (fs)	98		9.2	
Conventional (cfs)	158		4.9	
Difference [8]	**-60**	**0.030 ****	**4.7**	**0.600**
Semi-sustainable (ss)	123		7.6	
Conventional (css)	147		4.4	
Difference [5]	**-24**	**0.178**	**3.2**	**0.100 ***
Sust. all farmers (saf)	108		8.6	
Conv. all farmers (caf)	154		4.7	
Difference [13]	**-44**	**0.011 ****	**3.9**	**0.103**

For symbol definition: see footnote Table 5.3

In Table 5.11 figures are shown for the size and the age of the biggest tractor on the surveyed farms. From these figures it can be seen that the average size of the biggest tractor on cfs and saf farms was larger than that on fs and caf farms, respectively ($p < 0.05$). The age of the tractor was found to be higher for the group of ss farmers than for the css farmers (p = 0.1).

Although a difference in the size and age of the machinery and equipment between the two groups could well contribute to relatively low depreciation costs for sustainable farmers, the last factor mentioned above, comfort, could also be of importance. Indeed, at least two conventional farmers commented upon the fact that their sustainable neighbours 'did not even have air-conditioning on their tractor'.

The costs discussed above pertain to costs on farms with an established production system. Relative expenditure on machinery and equipment could be different when the comparison takes place at the stage of transition to sustainable farming. It is possible that sustainable farmers might need different machinery from that used in conventional agriculture (for example, tillage equipment). In order to assess this need the question was asked: 'Was any special machinery or equipment needed after the change from conventional to sustainable farming?'. The answers are recorded in Table 5.12.

Table 5.12: Need for special machinery or equipment at time of transition from conventional to sustainable farming

	Yes	No	N.A.	Total
Fully sustainable (fs)	3	3	2	8
Semi-sustainable (ss)	3	2	0	5
Sust. all farm (saf)	6	5	2	13

N.A. = not applicable

Half the farmers who had made the change were of the opinion that special machinery (mainly tillage equipment, see Section 5.4.1.9) was needed. The answers did not necessarily imply that it was also acquired. As farmers had used sustainable practices for a considerable time (see Section 5.5.2), it is not likely that the new machinery, if bought at the time of transition, affected the depreciation values heavily.

5.4.1.7 Labour

Permanent labour is an indivisible input. In many cases there was one permanent worker on the farm, while the spouse usually was engaged in some, but not full-time, farm labour. In some cases the farm was in transition from one generation to the next, which involved two full-time workers on the farm. In most cases family labour was supplemented with casual labour, which included shearers. Contract work carried out on the farm was not included as labour, but as services.

Table 5.13: Labour use per hectare

	Hired	Family	Total	
	$/ha	$/ha	$/ha	p-value
Fully sustainable (fs)	8.6	26.4	34.9	
Conventional (cfs)	4.5	36.5	40.9	
Difference [8]	**4.1**	**-10.1**	**-6.0**	**0.363**
Semi-sustainable (ss)	4.1	18.8	23.0	
Conventional (css)	3.9	13.1	17.0	
Difference [5]	**0.2**	**5.8**	**6.0**	**0.787**
Sust. all farmers (saf)	6.9	23.5	30.3	
Conv. all farmers (caf)	4.3	27.5	31.7	
Difference [13]	**2.6**	**-4.0**	**-1.4**	**0.727**

For symbol definition: see footnote Table 5.3

The figures presented in Table 5.13 are in dollars. Since wages paid reflect time of employment times wage rates, these figures might not be a good indication of total work carried out. However, as no data were collected on the number of days worked by shearers, and a cursory examination of the wage rate did not reveal large variations in this variable, it was decided to present wages in dollar terms. In total, the labour input on the two types of farms was similar ($p > 0.1$).

Sustainable farmers were asked whether their need for labour had changed when they converted to sustainable agriculture. Of the 11 producers for whom the question was relevant, none indicated an extra requirement.

5.4.1.8 Land

Land is an input in the agricultural production process. Its value could be expressed as an annual cost. For example, a certain interest rate could be employed to calculate income foregone from this input. On the other hand, the value of the land is included in the returns to capital and management, to be analysed in Section 5.4.3. In this section the values are discussed only to compare the quality of the land used in the two systems.

All producers included in the survey were broadacre farmers. However, since the size of the property was the least important criterion for selection of the conventional comparison, it would not have been surprising if differences in area operated between the two groups of producers existed. On the other hand, there are no reasons why a difference should be assumed a priori. No differences were detected between the sustainable and conventional farmers ($p > 0.1$) (Table 5.14).

Similar soil type and location were the important considerations in the choice of conventional counterparts. It is therefore to be expected that the unimproved capital value (ucv) was similar between the two groups of farms. Although this was true for the fs and cfs farms, and also for the saf and caf farms, ucv's of the ss farms were significantly lower then those of the conventional farms with which they were compared (Table 5.14). The difference was 17.5 per cent, and could be due to two factors.

Table 5.14: Area operated and land values

	Area Oper.		Unimpr.Cap.Val.		Impr.Cap.Val.	
	Ha	p-val.	$/ha	p-val.	$/ha	p-val.
Fully sustainable (fs)	755		782		1011	
Conventional (cfs)	928		723		1038	
Difference [8]	**-173**	**1.000**	**59**	**0.363**	**-28**	**0.726**
Semi-sustainable (ss)	1232		227		369	
Conventional (css)	2179		278		393	
Difference [5]	**-947**	**0.178**	**-51**	**0.059 ***	**-24**	**0.584**
Sust. all farmers (saf)	938		569		764	
Conv. all farmers (caf)	1409		552		790	
Difference [13]	**-471**	**0.124**	**16**	**0.834**	**-26**	**0.367**

For symbol definition: see footnote Table 5.3

First, the difference of value of the buildings for insurance purposes and in the sale of land could be important. For those of the ss farmers for whom the ucv was lower than for the counterparts, the area operated was also smaller. The ucv is the improved capital value (icv) minus the value of the operator's house, farm buildings, fences and non-portable water arrangements. The estimates of values of the buildings were often based on the value for which the farmer insured them, and are likely not to be proportionate to the size of the farm; that is, the smaller properties are relatively heavily capitalised regarding buildings. However, the icv might be more influenced by the productivity of the land, and less by the value of the buildings, especially the operator's house. Consequently, when the building values are deducted from the icv, to obtain the ucv, a relatively high value per hectare is deducted for the smaller properties.

Second, arable area as a percentage of total area operated was significantly lower on the ss than on the css farms (p = 0.100) (see Table

5.15). This may decrease the average price per hectare operated (see below).

Table 5.15: Arable area

	Ha	p-value	% of area operated	p-value
Fully sustainable (fs)	537		74	
Conventional (cfs)	652		82	
Difference [8]	**-115**	**0.726**	**-8**	**0.107**
Semi-sustainable (ss)	1048		82	
Conventional (css)	1986		89	
Difference [5]	**-938**	**0.106**	**-7**	**0.100 ***
Sust. all farmers (saf)	734		77	
Conv. all farmers (caf)	1165		85	
Difference [13]	**-431**	**0.124**	**-8**	**0.011 ****

For symbol definition: see footnote Table 5.3

There was a considerable difference between the fs and ss farms, both in sizes and values of the properties. The fs farms ranged in size from 377 to 1417 hectare, while the corresponding figures for the ss farms were from 575 to 1821 hectares. Similarly, the range of improved capital value of the fs farms was $422 to $1932 per hectare (with the second lowest value at $726), and of the ss farms from $211 to $597 per hectare. The differences were significant (p = 0.034 for farm area operated, and p = 0.005 for icv, calculated with a Mann-Whitney one-tailed test). The annual rainfall, often the limiting factor in Australian crop growing areas, where the fs farmer with the lowest icv lived was 450 mm. The farmer with the second lowest icv was in an area with somewhat less (430 mm) but possibly more reliable rainfall. The other fs farms were all in higher rainfall areas. The ss grower with the highest icv received on average 450 mm of rainfall annually, and the ss grower with the lowest icv 325 mm. The others were in areas where the annual rainfall was between 325 mm and 450 mm. This means that the ss farms in this survey were located in more marginal crop-growing areas than the fs farms.

To obtain a more complete picture of the difference in quality of the sustainable and conventional properties, the estimate for the arable area as a percentage of total area operated is included (Table 5.15). On average, less arable area was available on the sustainable farms (saf) than on the conventional farms (caf) (p = 0.011), although no difference could be shown for the fs-cfs groups of farms (p = 0.107). There is no obvious reason why arable area as a percentage of the total area operated is lower on sustainable farms than on conventional farms. As this variable was a subjective estimate by farmers, it could be argued that sustainable classify an area more easily as non-arable than conventional farmers do. This would conform with the notion that sustainable farmers emphasise soil quality as a main aspect of farming, and that they are therefore more reluctant to crop marginal soil, and hence classify it as non-arable.

Table 5.16: Area cropped

	Ha	p-value	% of arable area	p-value
Fully sustainable (fs)	231		47	
Conventional (cfs)	518		77	
Difference [8]	**-287**	**0.071 ****	**-30**	**0.007 *****
Semi-sustainable (ss)	457		44	
Conventional (css)	1070		51	
Difference [5]	**-613**	**0.089 ***	**-8**	**0.295**
Sust. all farmers (saf)	318		46	
Conv. all farmers (caf)	731		67	
Difference [13]	**-412**	**0.018 ****	**-21**	**0.009 *****

For symbol definition: see footnote Table 5.3

It is to be expected that land under sustainable management is rotated differently than that under conventional management. Averages of hectares cropped were lower for all groups of sustainable farms than for those of their counterparts ($p < 0.1$) (see Table 5.16). In relative terms (cropped area as a percentage of arable area), the fs and saf groups cropped less than the cfs and caf, respectively ($p < 0.05$) (one-tailed test). Eleven of the 13 sustainable farmers cropped a lower percentage of their arable area than their conventional counterparts. The 2 farms on which more was cropped were both ss farms.

Table 5.17: Change in land values as perceived by sustainable and conventional farmers, due to the sustainable production system

		No Change	Up	Down	N.A.	Total
Fully sustainable	(fs)	4	3	0	1	8
Conventional	(cfs)	6	2	0	0	8
Semi-sustainable	(ss)	4	1	0	0	5
Conventional	(css)	4	1	0	0	5
Sust. all farmers	(saf)	8	4	0	1	13
Conv. all farmers	(caf)	10	3	0	0	13

N.A. = not available

One of the objectives of rotating land in different crops is to increase soil fertility. As it was anticipated that sustainable farmers would rotate crops in a different way from conventional farmers, the question was asked of all farmers: 'If the sustainable farm were sold now, would the price be different because it has been managed in the sustainable way?'. Assuming that the farm would be sold to a conventional farmer, the question was intended to get information about how both types of farmers thought that conventional producers regarded the effect of the sustainable production system on the soil. The answers are recorded in Table 5.17.

Of the 25 farmers who expressed an opinion, none felt that the quality of the sustainable farm had decreased due to the system practised. Most farmers, sustainable (8) and conventional (10), did not think that the sustainable farm had changed in value. Approximately one quarter of all producers, 7, felt that the quality of the farm had improved, in the opinion of the conventional farmers, to the extent that it was expected to increase the value of the farm. In only one case did both farmers of 1 pair expect that a higher price would be paid for the sustainable property if sold under present conditions than if it had been farmed with conventional practices. The sustainable farmer expected an extra price of $170 per hectare (an increase of 23 per cent), while the conventional farmer said he would be willing to pay $125 (17 per cent increase) per hectare more for that farm than for other farms around it (indicating that it was not the position of the farm which caused the willingness to pay more). The same conventional farmer also (unsolicited) expanded upon differences in effect of the farming systems on the soil. Comments such as: 'We did not do our land much good, but we made money. Now we have to pay for it' and 'He [the sustainable farmer] has higher yields because his soil is better, due to his farming practice' are more extreme than those heard from most other conventional farmers, but they are by no means exceptional in general sentiment. Another comment, relayed by an officer of one of the Departments of Agriculture visited, was made by a local conventional farmer about the difference between a particular sustainable farmer in that area and conventional farmers. 'The difference is that X will still have soil left in 20 years time, while we won't.' The conventional farmer was considered to be an excellent manager by the Department of Agriculture officer.

Although, in general, comments made on sustainable farming were positive, some conventional farmers commented negatively upon an excessive presence of weeds on sustainable farms. The same complaint was made by some sustainable farmers against their conventional neighbours.

5.4.1.9 Cultivation practices

Cultivation practices are practices by which the land is prepared for planting. They are influenced by, and influence, the combination of inputs used. They are carried out by farm labour, with the help of machinery and implements and, in a broader sense, with livestock and controlled burning. The aim of the cultivation in relation to present and future soil nutrient status and structure and weed management considerably influences the kind of implement or method used, and the frequency with which, and time at which they are used. They are also influenced by the degree of use of other inputs, such as fertiliser and pesticides, and of management tools such as crop rotations. The combination of these inputs and techniques affects the present and future productivity of land.

Weeds and crop residues are a source of nutrients for both soil and stock. In addition, the presence of organic matter can influence future yields through its effect on soil structure, affecting characteristics such as water infiltration rate and soil porosity. On the other hand, problems may result from incorporation of crop stubble and weeds into the soil, or retention on top of the soil. The accumulation of material may hinder the operation of cultivation and planting, and may decrease the germination rate. Weeds provide competition for a future crop. An increase of crop disease and pest incidence is also attributed to the presence of crop residues.

The availability of synthetic fertilisers and pesticides decreases the value of organic material as a nutrient source. As conventional and sustainable farmers differ in their opinions about the advisability of using these inputs in the production process, differences in use of the organic matter between the two systems should be expected. Cultivation practices reflect these differences.

In the past, the burning of stubble prior to cropping has been the conventional way of decreasing the amount of organic matter. This practice also aids weed management. It is only in recent years that the burning of fields before cultivation has diminished in importance. This is mainly due to the realisation that the presence of organic matter can decrease wind or water erosion of the soil (Sims 1977, p.247; Clarke 1986, p.278).

The realisation of the importance of organic matter, together with that of the cultivation method on the extent of soil degradation gave rise to the development of a new technology: 'minimum tillage'. The objective of this technology is to minimise mechanical disturbance of the soil, which is achieved by a decreased number of cultivations before sowing. It involves extensive use of herbicides and the use of machinery designed to cope with the increase in organic matter. The use of pre-emergent herbicides, applied in the spring before weeds seed, is an extension of this technology. Apart from continuing to provide a soil cover, it has the advantage over early cultivation of providing some grazing for stock.

Organic matter is of such importance to sustainable farmers, that ways were found to handle the disadvantages of retaining it. Some farmers mentioned that, in the first seasons after transition, the build-up of trash (organic matter) in cultivation equipment was a real problem, causing blockages of machinery and bad germination rates of seed. Some reported home-devised adjustments of machinery to cope with this problem (machinery suitable for the purpose was less easy to buy in the past than it is at present). The disappearance of it after a few seasons, presumably due to the build-up of organisms in the soil which break down organic material, was also commented upon. The problem of weeds was handled mainly by mechanical cultivation, and by strategic use of livestock.

In practice, of course, the method of seedbed preparation is chosen for a number of purposes. In Table 5.18 are shown the main methods used by the interviewed farmers for the handling of organic matter on the soil. The data are derived from the farmers' description of their practices. Although a farmer might use a combination of techniques, only the main ways of managing organic matter and weeds are included here. For example, the two conventional farmers who are registered under the heading burn/stock also cultivated their land before planting. However, less emphasis was put on the cultivation <u>because</u> stock and fire had been used previously. Herbicides are not included in the table, but were used by all conventional farmers.

Table 5.18: Main ways of dealing with organic matter and weeds for next year's crop (number of pairs of farmers

	Conventional farmers				**Total S.F.**
	Mech.	Burn/ Mech.	Stock/ Mech.	Burn/ Stock	
Sustainable Farmers					
Mech.	2	2	1	2	**7**
Burn/ Mech.	0	0	0	0	**0**
Stock/ Mech.	2	2	0	0	**4**
Burn/ Stock	1	0	0	0	**1**
Total C.F.	**5**	**4**	**1**	**2**	**12**

Mech. = Mechanical cultivation S.F. = Sustainable farmers
C.F. = Conventional farmers

Of necessity, this table has an element of subjectivity in it, and should therefore be taken as an indication only of differences in seedbed preparation between sustainable and conventional farming. The table is presented in a form which allows a comparison of pairs of farmers, because cultivation practices depend on local conditions.

Three points arise from the data presented in Table 5.18. The first is that mechanical cultivation is an important means of seedbed preparation in both systems. It accounts for (when used alone or together with burning or stock) 11 of the 12 available observations of the sustainable farmers, and 10 of the 12 of the conventional producers.

The second point is that for six conventional farmers burning was an important management tool, while it was of very little interest to sustainable farmers. The virtual absence of observations for sustainable farmers under 'burn' does not mean that none of this group ever burns the paddock. Rather, it indicates that burning is not practised commonly. To the question: 'Do you burn your stubble before cropping?' nine sustainable, and four conventional farmers answered in the negative, while one sustainable farmer and six conventional farmers answered in the affirmative. The rest, three sustainable and three conventional producers, burned their paddocks sporadically, and preferred to avoid it.

The third point is that cultivation methods do not appear to be strongly correlated with location. Only two pairs of farmers use mechanical cultivation as their main method of dealing with organic matter and weeds. None of the other sustainable farmers used the same method as the conventional neighbour.

Two other aspects of cultivation practices are of importance when considering the effect on the long-term productivity of the soil: the timing of the cultivations and the type of implement used.

In the past, clean cultivated fallows, first cultivated in the spring and kept clean of weeds by subsequent 'workings' before cropping in the autumn, were used to accumulate soil moisture (Sims 1977, p.244). The first cultivation was carried out with the mouldboard plough, which inverts the soil. The practice of working the fallows, however, was criticised as early as the 1930s on the grounds of its effect on soil erosion. Over time, a shift of timing of the first cultivation has occurred towards autumn cultivation.

There does not appear to be a difference in timing of cultivations between the practitioners of the two systems. Most of the pairs of farmers carried out the first cultivation at similar times, that is, within one month of each other. Three of the sustainable farmers started cultivating more than one month before their counterparts, while two started more than one month later. For some, this involved the difference between spring and autumn cultivation.

Recommendations for cultivation implements have also changed over time. The use of the mouldboard plough was still seen as being preferable to that of the disc plough and cultivator in the 1950s (Sims 1977, p.247). However, more recently the disc plough, and subsequently the scarifier and chisel plough were considered to be more suitable for Australian conditions. This indicates a trend towards '...less inversion of the seedbed and less aggressive soil manipulation. Crop residues are deliberately left as a protective soil mulch by modern implements' (Clarke 1986, p.278).

In Table 5.19 is shown the main implement of cultivation used following a grazing phase, and in Table 5.20 the main implement after a crop. All farmers use some type of tined implement. However, the implement shown in Tables 5.19 and 5.20 is the main piece of equipment to carry out the first cultivation, which is usually the heaviest part of the work.

Table 5.19: Main cultivation implement used when cropping after a pasture phase (number of pairs of farmers)

	Conventional farmers			**Total S.F.**
Category	0	1	2	
Sustainable Farmers				
1	1	1	2	**4**
2	0	2	2	**4**
3	1	2	0	**3**
Total C.F.	**2**	**5**	**4**	**11**

Categories:
0 = no cultivation (that is, no pasture phase)
1 = disc plough 2 = cultivator 3 = agrow-plow
S.F. = sustainable farmers C.F. = conventional farmers

Table 5.20: Main cultivation implement used when cropping after a crop number of pairs of farmers)

	Conventional farmers				**Total S.F.**
Category	0	1	2	4	
Sustainable Farmers					
0	2	2	0	0	**4**
1	0	1	1	1	**3**
2	0	0	1	0	**1**
3	0	0	2	1	**3**
Total C.F.	**2**	**3**	**4**	**2**	**11**

Categories:
0 = no cultivation (no crop after crop in rotation) 1 = disc plough
2 = tine implement 3 = agrow-plow 4 = chisel plough
S.F. = sustainable farmers C.F. = conventional farmers

From the two tables it is clear that the disc plough and some type of tined implement are popular amongst both sustainable and conventional farmers. The difference between the use of implements in the two systems is that some of the sustainable farmers used the agrow-plow, which aerates the soil due to a shaking movement of the tines during cultivation (3 out of 11 farmers for crop after pasture, and 3 out of 7 for crop after crop). The chisel plough, which is similar to the agrow-plow without the shaking movement is used by some conventional farmers when preparing the soil for a crop after a crop in the previous year (2 out of 9).

In summary, the sustainable farmers in the survey made greater use of organic material than the conventional farmers. They burned stubble to a lesser extent, and developed trash-handling capabilities. Timing of cultivation was similar on the two types of farms. Sustainable farmers possibly tended more towards tined implements than conventional farmers, especially when cultivating the soil after the pasture phase.

5.4.1.10 Concluding Remarks

The inputs discussed above (fertilisers, pesticides, interest, fuel, and labour) are those making up the main costs on conventional farms. Of the total input costs of $128 per hectare operated for cfs farmers (see Table 5.29) $75 (or 59 per cent) was spent on those five inputs. Comparable figures for the css farmers were $46 of a total of $81 (or 57 per cent). The ss farmers showed the same pattern of expenditure as the two conventional groups, with $34 of $55 (or 62 per cent) expenditure on fertilisers, pesticides, interest, fuel and labour. However, the expenditure pattern of the fs farmers was different. These producers spent, on average, only 38 per cent ($29 of $76) on those five inputs.

Since one of the criterion for the selection of the sustainable farmers was that they used little or no synthetic fertilisers and pesticides, differences between them and their conventional counterparts would be expected, and are shown in Table 5.21. However, from this table the differences between the two groups of sustainable farmers, relative to the conventional counterparts, are also apparent. In absolute terms the difference with the conventional producers was almost five times larger for the fs than for the ss farms ($29.8 and $6.3 respectively).

Sustainable farming also differs from conventional farming in area cropped as a percentage of the arable area. However, this difference could not be established between the ss and css group.

None of the other inputs was *a priori* assumed to be used differently in the two systems. However, expenditure on fuel, and machinery and equipment per hectare operated was lower for the fs than for the cfs farmers (see Table 5.21). This was due to the fact that, although similar costs were incurred per hectare cropped by the two groups (as in the case of the ss-css producers), fs farmers cropped less than the cfs farmers. Smaller size, lower age and less comfort of machinery and equipment are all likely to play a part in the lower depreciation cost for sustainable producers.

Table 5.21: Differences in expenditure on main cash inputs per area operated: sustainable minus conventional

Input	Type of Farmers					
	fs farmers		ss farmers		saf farmers	
	$/ha oper.	p-value	$/ha oper.	p-value	$/ha oper.	p-value
Fertilisers	-16.1	0.018 **	-3.4	0.030 **	-11.2	0.002 ***
Pesticides	-13.7	0.007 ***	-2.9	0.030 **	-9.5	0.001 ***
Interest	-11.2	0.363	-6.2	0.787	-9.3	0.328
Fuel	-9.9	0.030 **	-0.2	0.590	-6.2	0.025 **
Mach. & Eq.	-42.5	0.080 *	-1.8	1.000	-26.9	0.069 *
Hired labour	4.1		0.2		2.6	

For symbol definition: see footnote Table 5.3

5.4.2 Outputs and output prices

5.4.2.1 Crops

Cereals were grown on all surveyed farms. In most cases this meant that wheat was the main crop grown. On one cfs farm, however, wheat could not be grown any longer due to eelworm infestation. The farmer considered that it had become financially unattractive to combat this with pesticides. This pair of farmers was excluded from the analysis of yield difference. On two other pairs of farms (both ss-css) barley was the main crop grown. This was common on farms in the whole area, and not peculiar to the farms in the survey. They were included in the average 'wheat yield'.

Differences in wheat yield between the two types of farms were not statistically significant for any of the groups ($p > 0.1$) (Table 5.22).

The (weighted) average in the ABARE survey (calculated as the total of the value for each State in which a sustainable farmer was interviewed multiplied by the number of interviewed sustainable farmers in that State, divided by the total number of interviewed sustainable farmers) was 1.6 tonnes per hectare. The difference between the ABARE figure and those obtained in this survey suggests that the fs and cfs producers especially practise in better farm areas than the average farmer in the ABARE survey. Although the yield figure for the css-farmers (1.7 tonnes per hectare) is similar to that of the ABARE (and significantly different from the figure for cfs farmers with a one-tailed Mann-Whitney test (p = 0.038)), it includes two barley yields. It is therefore not strictly comparable to the ABARE and cfs averages.

Table 5.22: Wheat yield, area in wheat and number of other crops

	Wheat				Non-wheat crops	
	Yield		% of total area cropped		Number per farm	
	t/ha	p-value	%	p-value	Number	p-value
Fully sustainable (fs)	2.4		55.8		4.6	
Conventional (cfs)	2.5		62.4		4.0	
Difference [7,7,8]	**-0.1**	**0.673**	**-6.0**	**0.224**	**0.6**	**0.343**
Semi-sustainable (ss)	1.1		37.3		3.6	
Conventional (css)	1.7		51.2		2.8	
Difference [5,5,5]	**-0.6**	**0.178**	**-13.9**	**0.059 ***	**0.8**	**0.217**
Sust. all farmers (saf)	1.9		48.1		4.2	
Conv. all farmers (caf)	2.2		57.7		3.5	
Difference [12,12,13]	**-0.3**	**0.170**	**-9.6**	**0.016 ****	**0.7**	**0.182**

For symbol definition: see footnote Table 5.3

Yield figures for one year do not give a full picture of all important aspects of productivity. Two facets in particular are of interest in connection with a study on sustainable agriculture. First, Klepper et al. (1977) have pointed out that it is possible that the relative yields of the two systems change according to climatic conditions. According to many of the surveyed sustainable farmers, in climatically favourable years yields can be obtained on conventional farms which are not equalled on sustainable farms. Conversely, crops on sustainable farms might suffer less from dry conditions resulting in relatively high yields on these farms in climatically adverse conditions. Second, it is possible that crop yields drop in the initial stages of transition from conventional to sustainable farming (see, for example, Lampkin 1986b). These aspects are discussed further in Chapter 6.

Apart from climatic conditions and managerial skills, yields are influenced by soil fertility and pests. One way to manage these two factors is to diversify cropping. Diversification is measured in two ways: area of wheat as a percentage of total area cropped, and the number of crops grown. Since it is expected that crop diversification would be practised more extensively on sustainable than on conventional farms, one-tailed tests were carried out for both these variables. The results are shown in Table 5.22.

Wheat area as a percentage of total area cropped was smaller on ss and saf farms than on those of the conventional counterparts ($p < 0.05$). No statistical difference could be found for any of the groups for the second measure of diversification, the number of crops per farm. This might be partly due to the fact that five pairs of farms had the same number of crops grown. The Wilcoxon-test automatically eliminates observation with zero difference, so that the test was carried out on only 8 saf-caf farms (5 fs-cfs farms and 3 ss-css farms).

In Table 5.23 receipts from wheat are shown. Three measures of receipt were calculated: per tonne, per hectare of wheat, and as a percentage of total crop receipts.

As wheat from sustainable farms is perceived by some consumers to be of higher quality than that produced on conventional farms (see Section 3.5.3), relatively high prices can be paid for this type of wheat per tonne. The hypothesis in this case is therefore that wheat prices received by fs farmers are higher than those received by cfs farmers (one-tailed test). As the ss farmers did not strictly adhere to 'organic standards' it was expected that those farmers did not receive a premium. The two-tailed test was applied for this group of farmers and for the saf farmers.

Although some perceive produce from sustainable farms to be of higher quality, the reverse is also true (R.L. Cracknell, Australian Wheat Board, personal communication, 1987). An attempt was made to gather information about that aspect of quality which can be measured with current technology: the wheat protein content. However, this was soon abandoned, since farmers generally only knew the protein content of parts of the harvest with exceptionally high or low readings. Several sustainable farmers, however, reported relatively high protein readings. Levels obtained by them of over 15 per cent of protein for soft wheat, and over 19 per cent for hard wheat were purported by local Australian Wheat Board officials to be the highest of the area in the particular year. Since the average price of the fs farmers (see Wynen 1988b) and the ss farmers (see Table 5.23) who did not sell in a special market is similar to that of their conventional farmer counterparts, there is no reason to believe a priori that the crop is lower in quality.

Returns per unit of land depend on yield and on output prices. As yields between the two groups were expected to be similar, the test employed for receipts per hectare of wheat was the same as for expected output prices (one-tailed for fs, and two-tailed for ss and saf).

Wheat receipts as a percentage of total crop receipts (see Table 5.23) were assumed a priori to be lower only for the ss farms. This was because for this group one of the two components, the percentage of wheat area of total cropped area, was shown to be lower than for conventional farmers (see Table 5.22), while the second component, price, was similar to that of the conventional counterparts (see Table 5.23). The wheat receipts relative to total receipts were assumed to be higher on the fs than on the cfs farms, due to similar wheat area as a percentage of total cropped area, while prices per tonne of wheat for the fs producers were higher. Thus, wheat receipts as a percentage of total crop receipts were assumed to be higher for fs than for cfs farmers (one-tailed test). Because of the counteracting forces in the two groups of sustainable farmers a two-tailed test was applied for the saf-caf group.

Table 5.23: Wheat cropping: receipts per tonne, per hectare and as a percentage of total crop receipts

	$/t	p-value	$/ha	p-value	%	p-value
Fully sust. (fs)	161		403		67.0	
Conventional (cfs)	124		322		71.3	
Difference [7]	**36**	**0.018 ****	**82**	**0.277**	**-4.4**	**0.136**
Semi-sust. (ss)	118		131		45.2	
Conventional (css)	119		202		64.5	
Difference [5]	**-1**	**0.855**	**-72**	**0.178**	**-19.2**	**0.030 ****
Sust. all farms (saf)	143		290		57.9	
Conv. all farms (caf)	122		272		68.5	
Difference [12]	**21**	**0.032 ****	**18**	**0.845**	**-10.6**	**0.038 ****

For symbol definition: see footnote Table 5.3

In practice, not all fs farmers marketed their wheat in the special market: three sold all wheat in the conventional market, and two received premium prices for the whole wheat crop. The other three marketed part in the conventional, and part in the sustainable market. None of the ss farmers sold their wheat at a premium. The unweighted average wheat price per tonne for the seven fs farmers was $161 as compared to $124 for their conventional counterparts (Table 5.23), a significant difference (p = 0.018). These values were net of transport and handling charges, and included also estimates for produce stored on the farm.

Some sustainable farmers sold produce in small quantities, sometimes milled. Income derived from services such as packaging and milling was excluded here. The values include income due to locating a special market, something which is required in order to be able to sell in such a market.

The receipts per hectare of wheat of all groups of sustainable farms were similar to those on conventional farms (p > 0.1).

Receipts from wheat as a percentage of total receipts from crops were similar for the fs and cfs farmers. However, the ss farmers received significantly less from wheat (p = 0.030), which is to be expected when comparatively little wheat is grown (see Table 5.22). The same was the case for all 13 sustainable farmers together (p = 0.045).

Table 5.24: Non-wheat crops: receipts per hectare

	$/ha	p-value
Fully sustainable (fs)	277	
Conventional (cfs)	287	
Difference [7]	**-10**	**0.467**
Semi-sustainable (ss)	92	
Conventional (css)	111	
Difference [5]	**-19**	**0.590**
Sust. all farmers (saf)	200	
Conv. all farmers (caf)	213	
Difference [12]	**-14**	**0.610**

For symbol definition: see footnote Table 5.3

In Table 5.24 receipts per hectare from non-wheat crops are shown. These receipts depend on the actual crops included in the rotation, and the product prices. As no differences in number of crops could be shown (Table 5.22) between the two types of farms a hypothesis, that receipts from (less financially rewarding) non-wheat crops per hectare are similar on sustainable and conventional farms, would be logical. However, fs farmers might sell these crops for a premium, which is the reason for a one-tailed test for this group. Since no price differences are expected between produce from ss and css farms, a two-tailed test is applied to their receipts. Results were found not to be different for any of the groups (p > 0.1).

In Table 5.25 are shown receipts from all crops combined per hectare cropped, and per hectare operated. The values consist of several components, to which different assumptions about the differences between the sustainable and conventional farmers may apply. For this reason the two-tailed test was applied.

Table 5.25: Receipts from all crops per hectare cropped and operated

	$/ha cropped	p-value	$/ha operated	p-value
Fully sustainable (fs)	332		115	
Conventional (cfs)	316		233	
Difference [8]	**17**	**0.834**	**-117**	**0.042 ****
Semi-sustainable (ss)	107		32	
Conventional (css)	159		71	
Difference [5]	**-52**	**0.178**	**-39**	**0.059 ***
Sust. all farmers (saf)	246		83	
Conv. all farmers (caf)	256		171	
Difference [13]	**-10**	**0.675**	**-87**	**0.008 *****

For symbol definition: see footnote Table 5.3

No difference was found between sustainable and conventional farmers regarding crop receipts per area cropped (p > 0.1). Receipts from crops per area operated, however, were lower for sustainable than for conventional producers ($p < 0.1$).

5.4.2.2 Livestock

Generally in the Australian broadacre cropping areas, stock is kept to utilise resources on the farm which cannot be used otherwise, such as non-arable areas. A perceived need for a non-cropping period in the cropping schedule often also makes some of the land available for stocking each year. In addition, stock may be used as a diversification of the cropping enterprise, which spreads risks.

For sustainable farmers also other reasons exist to incorporate stock in the system, such as increase of soil nutrients and weed control. Several sustainable farmers in the survey mentioned that stock was essential for a sustainable farming system. Indeed, some had expanded into goats, mainly for the management of certain weeds which were not adequately kept under control by the traditional types of stock (sheep and cattle). Although on conventional farms stock is also used for weed control, it is not seen as essential in this regard. Indeed, three out of the eight cfs farmers did not have any stock at all.

Limits for stock numbers are imposed by stock carrying capacity of the area. A farmer's decision is influenced not only by climate and soil type, but also by factors such as expectation about government policies in times of climatically adverse conditions, risk aversion, and judgement about the long-term effects of different stocking rates on soil quality.

Stocking rates (number of sheep and goats plus eight times the number of cattle) are calculated per area available to stock for grazing (that is, total area operated minus area cropped). To decide whether a one-tailed or two-tailed test would be appropriate to test for differences between the systems for this variable, three factors need to be considered. One, sustainable farmers, more so than conventional farmers, employ stock as a management tool for which a high stocking rate is beneficial (decrease of weeds). Two, concern for soil quality is usually a major consideration for choice of the sustainable production system. This means that a conservative approach can be expected from sustainable farmers with regard to stocking rates. Three, as the fs farmers crop a lower percentage of the arable land (which generally has a higher carrying capacity than the non-arable land) than cfs producers, it could be expected that the area available for grazing on fs is, on average, of higher quality than that on cfs farms. This means that the carrying capacity on average could be expected to be higher on sustainable farms. To overcome this problem, the measure of area available for grazing is calculated as three times the non-cropped arable area plus the non-arable grazing area. This figure reflects the consensus between two farmers and a Department of Agriculture officer in the Eastern Riverina. Although it is likely that the ratio is not the same for each area, it was considered a better approximation of the reality than the alternative, the total area available for grazing. Since the first two factors are counterbalancing, and it is not clear which factor is the more important, a two-tailed test was applied.

Table 5.26: Stocking rates per non-cropped hectare

	Sheep	Beef	Total Stock	
	No./ha	No./ha	No./ha	p-value
Fully sustainable (fs)	1.07	0.11	1.91	
Conventional (cfs)	0.93	0.04	1.27	
Difference [5]	**0.14**	**0.06**	**0.64**	**0.178**
Semi-sustainable (ss)	0.83	0.01	0.91	
Conventional (css)	0.90	0.01	0.95	
Difference [5]	**-0.07**	**0.00**	**-0.04**	**0.893**
Sust. all farmers (saf)	0.95	0.06	1.41	
Conv. all farmers (caf)	0.91	0.02	1.11	
Difference [10]	**0.03**	**0.03**	**0.30**	**0.333**

For symbol definition: see footnote Table 5.3

In the survey, stock was kept on all of the sustainable farms, while on three of the eight cfs farms only cropping took place. The total stock per grazing area was similar for the two types of farms for all three groups if those three pairs of farmers were excluded (p > 0.1) (see Table 5.26). If all farms were included the stocking rate per hectare operated was significantly higher for fs (2.19) than for cfs (0.97) farmers (p = 0.021) (not shown in the table).

A comparison of the physical outputs of livestock is somewhat complicated by the fact that there are many different combinations of output possible. Livestock products include wool, and meat of sheep and cattle. Not only can stock be kept for different purposes, such as for the production of wool or meat, differences can also exist in combination of stock. This makes comparison of physical output difficult. The financial returns to stocking, which allows outputs to be expressed in the same unit, enable easy comparison of the total livestock production. However, even in such a comparison not all benefits and costs are counted. Examples are output increases due to weed control and soil fertilisation by stock.

Table 5.27: Wool yield

	kgs/sheep	p-value
Fully sustainable (fs)	4.7	
Conventional (cfs)	5.3	
Difference [4]	**-0.6**	**0.584**
Semi-sustainable (ss)	5.9	
Conventional (css)	6.5	
Difference [5]	**-0.6**	**0.590**
Sust. all farmers (saf)	5.4	
Conv. all farmers (caf)	6.0	
Difference [9]	**-0.6**	**0.343**

For symbol definition: see footnote Table 5.3

The physical measure which is somewhat comparable is wool per sheep. However, it should be borne in mind that the stocking rate (which includes sheep and beef), and the purpose for which sheep are kept (wool, meat, or a combination of the two) are important factors in determining wool yield. Although this measure is not a good indication of productivity per unit of land, it has been included here (Table 5.27). Because three cfs farmers did not keep any livestock at all, and three fs farmers kept solely beef, only four pairs of fs and cfs farmers were included. All ss and css farmers carried sheep. Wool yield was equal for all groups ($p > 0.1$).

Receipts for stock-related activities were calculated on the basis of per hectare of grazing area, and per total hectare operated (Table 5.28). For both these measures, no differences were registered for any of the three groups ($p > 0.1$). However, when all farms are included in the comparison, the average receipts from livestock per hectare operated (not shown in the table) is higher for sustainable farms ($44.4) than for the conventional farms ($22.0) ($p = 0.059$).

Table 5.28: Receipts from livestock per hectare grazed and operated

	$/ha grazed	p-value	$/ha operated	p-value
Fully sustainable (fs)	32.5		45.2	
Conventional (cfs)	30.7		35.4	
Difference [5]	**1.8**	**1.000**	**9.8**	**0.418**
Semi-sustainable (ss)	20.3		28.8	
Conventional (css)	20.1		24.7	
Difference [5]	**0.2**	**1.000**	**4.1**	**0.418**
Sust. all farmers (saf)	26.4		37.0	
Conv. all farmers (caf)	25.4		30.1	
Difference [10]	**1.0**	**0.919**	**6.9**	**0.221**

For symbol definition: see footnote Table 5.3

5.4.3 Returns to farming

Financial benefits from farming can be expressed in many different ways. The suitability of the measure depends on the purpose for which the figure is used. ABARE calculates the total cash costs (TCC), total cash receipts (TCR) and the farm cash operating surplus (FCOS equals TCR minus TCC). These three measures are of importance especially in the short term.

Non-cash costs (such as depreciation of machinery, equipment and farm buildings; and family labour), and benefits (such as an increase in stock) have to be incorporated in the returns to farming to obtain an indication of the long-term viability of the farm. Details of the measures included here are discussed in Campbell (1981) and in Appendix 6.

Table 5.29: Total cash costs (TCC), total cash receipts (TCR) and total farm cash operating surplus (FCOS) per hectare operated

	TCC		TCR		FCOS	
	$/ha	p-value	$/ha	p-value	$/ha	p-value
Fully sustainable (fs)	76		181		105	
Conventional (cfs)	128		262		134	
Difference [8]	**-52**	**0.021 ****	**-81**	**0.141**	**-28**	**0.944**
Semi-sustainable (ss)	55		65		10	
Conventional (css)	81		102		21	
Difference [5]	**-26**	**0.030 ****	**-37**	**0.178**	**-10**	**0.787**
Sust. all farmers (saf)	67		137		69	
Conv. all farmers (caf)	110		201		90	
Difference [13]	**-42**	**0.002 *****	**-64**	**0.050 ****	**-22**	**0.675**

For symbol definition: see footnote Table 5.3

In Table 5.29 are shown the total cash costs, cash receipts and farm cash operating surplus per hectare operated. As sustainable farmers spend less on some inputs than conventional farmers, the one-tailed test was applied for the total cash cost. For the other variables the two-tailed test was employed.

The total cash costs of sustainable farmers per hectare operated were lower than those of their conventional neighbours in all groups of comparison ($p < 0.05$).

The total cash receipts per hectare operated on the sustainable farms were lower than on the conventional farms for all farms together ($p = 0.05$). The hypothesis that the farm cash operating surplus was similar for the two types of farming could not be rejected for any of the groups ($p > 0.1$).

The relatively high returns per hectare of the fs and cfs farmers as compared to those of the ss and css farmers is likely to be another manifestation of the fact that the ss and css farmers live in a more marginal environment.

In the ABARE's calculations of the cash costs and benefits, only the cash part of the farm is included, not the change in stock (both crop and livestock), the change in value of capital items (such as machinery), and payment for family labour. For the purpose of this study, stored crop was estimated at prices received for sold crop and the calculated values were imputed and incorporated in the total cash receipts. If values for the other factors are taken into consideration, the resulting return, calculated per hectare operated and per unit of capital invested (the return to capital invested and management), could not be shown to differ between the two systems ($p > 0.1$) (Table 5.30).

The returns to capital and management include interest costs and rent for the farm. In order to compare the financial aspects of farming itself, the cost of interest and rent were deducted from the total cost of farming. These 'adjusted' figures showed no difference between the groups of sustainable and conventional farmers ($p > 0.1$) (Table 5.31).

Also between the cfs and css groups, no difference was detected for adjusted returns per hectare (p = 0.608) and adjusted returns per unit of capital invested (p = 1.000). However, the fs farmers had higher values for these measures than the ss producers (p = 0.034 and p = 0.007, respectively).

Table 5.30: Return to capital and management per hectare operated and per unit of capital invested

	$/ha oper.	p-value	% cap. inv.	p-value
Fully sustainable (fs)	36.8		3.03	
Conventional (cfs)	20.9		1.17	
Difference [8]	**15.9**	**0.363**	**1.86**	**0.183**
Semi-sustainable (ss)	-27.7		-6.06	
Conventional (css)	-9.4		-1.76	
Difference [5]	**-18.3**	**0.418**	**-4.30**	**0.418**
Sust. all farmers (saf)	12.0		-0.47	
Conv. all farmers (caf)	9.2		0.04	
Difference [13]	**2.8**	**0.834**	**-0.51**	**0.780**

For symbol definition: see footnote Table 5.3

It is sometimes suggested that the viability of sustainable farms depends on the higher prices received for produce relative to conventional prices. An attempt was made to get some indication of the influence of prices on the viability of the surveyed farms. For that purpose financial returns were calculated for the fs and cfs farmers assuming average cfs prices for the major crop, wheat. That is, premiums received for wheat produced under sustainable farming conditions were disregarded.

In Table 5.32 the same financial measures are shown as in Table 5.31 for the adjusted returns to the fs and cfs farmers. The difference is that these are calculated with conventional wheat prices (see Table 5.23). As can be expected, figures show a decrease in financial benefits for fs farmers. This results in a decrease in the gap between the two groups of farmers of the included variables. Also here, no statistical difference can be shown ($p > 0.1$).

Table 5.31: Adjusted return to capital and management per hectare operated and per unit of capital invested

	$/ha oper.	p-value	% cap. inv.	p-value
Fully sustainable (fs)	41.9		3.39	
Conventional (cfs)	37.3		2.18	
Difference [8]	**4.6**	**0.944**	**1.21**	**0.441**
Semi-sustainable (ss)	-12.5		-2.64	
Conventional (css)	12.0		2.22	
Difference [5]	**-24.5**	**0.106**	**-4.86**	**0.178**
Sust. all farmers (saf)	20.9		1.07	
Conv. all farmers (caf)	27.6		2.19	
Difference [13]	**-6.6**	**0.576**	**-1.13**	**0.576**

For symbol definition: see footnote Table 5.3

In connection with present and future output prices it should be mentioned that, since many of the conventional farmers were considered to be very good managers, it is quite likely that they are 'early adopters'. In times of low expected prices for traditional crops (such as wheat before the 1985-86 growing season), such farmers will consider growing alternative crops. Many of the conventional farmers interviewed were indeed growing crops which officers of the Department of Agriculture labelled 'new crops', such as dry beans and peas. Long-term profitability of these crops still needs to be assessed.

Table 5.32: Adjusted return to capital and management per hectare operated and per unit of capital invested with conventional wheat prices

	\$/ha oper.	p-value	% cap. inv.	p-value
Fully sustainable (fs)	31.1		2.46	
Conventional (cfs)	34.8		2.18	
Difference [8]	**-3.7**	**0.726**	**0.28**	**0.834**

For symbol definition: see footnote Table 5.3

An issue in comparing financial performance of sustainable and conventional farmers is the prices of crops relative to livestock and livestock products for 1985-86, as compared to other years. Since sustainable farmers are likely to have more livestock and less crop than conventional farmers, relative movements of the prices of the different enterprises can be important in determining relative profitability. In Table 5.33 the indexes of prices received by farmers in Australia are shown. From 1982-83 to 1986-87 the ratio of prices for wheat, the main crop on most surveyed farms, to prices for livestock and livestock products decreased considerably. In 1985-86 the ratio was similar to that of the two previous years, but higher than of the two following years.

Table 5.33: Indexes of prices received by farmers in Australia

	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88
Wheat	114	106	111	109	95	106
Livestock Sector	103	111	119	119	134	165
Wheat/Livestock	1.11	0.95	0.93	0.92	0.77	0.64

Source: BAE (1985b) and ABARE (1989).

This means that, if the analysis had been carried out on data for the two years previous to 1985-86, relative financial benefits for the two groups of farmers would not have differed from relative benefits in 1985-86 on account of output prices. However, in 1986-87 and 1987-88 prices for livestock increased absolutely and relative to wheat prices. This would benefit the sustainable farmers in general more than the conventional farmers, increasing the profitability of sustainable farming absolutely and relative to that of conventional farming in comparison with 1985-86.

5.4.4 Psychic income and farmers' perceptions of returns under sustainable farm management

In Section 5.4.3 it was shown that the net financial benefits from sustainable agriculture, for those farmers who were interviewed, were similar to those of conventional producers for 1985-86. There is no reason to believe that 1985-86 was a year exceptionally favourable to sustainable farming. However, despite the finding of similar incomes under the two farming systems, sustainable agriculture has not been widely adopted. This could be due to several reasons, such as: existence of costs in the transition from conventional to sustainable farming; similarity in total returns (including psychic income) derived from the two systems; existence of psychic costs of sustainable farming; and lack of information about the relative present and future returns to the two systems. Questions were included in the survey to provide information on some of these issues.

Farmers were asked which management system they would choose if the net financial benefits of sustainable and conventional farming were equal. As the financial returns to sustainable farming can be the same as those of conventional farming, this question was designed to assess the farmers' perceptions of the relative returns to the two management system.

All sustainable farmers indicated that, in the case of equal returns, they would farm in the sustainable way. Most of these farmers had changed to sustainable farming in times when the cost of information (including costs in the form of returns foregone through errors made) and psychic costs were likely to have been high. With similar present net financial returns, non-financial benefits must have been derived by these farmers from the sustainable management system in the past (see Section 5.5.3.1). Present net financial plus psychic income from sustainable farming must be perceived by these producers as at least equal to that from conventional farming.

Ten out of the 13 conventional farmers also said that they would choose sustainable agriculture if returns to the two systems were equal. A typical comment added to the answer was: 'Who would want to spray if it is not needed?'. This indicates that these farmers perceived net financial returns from sustainable farming to be lower than returns from conventional agriculture.

This led to an attempt to estimate the psychic income attributable to the choice of the management system. All sustainable farmers, and the three conventional farmers who would stay with their own management system if the net financial returns of the two systems were similar were asked: 'Assuming that the net incomes from sustainable and conventional farming are equal, if you had the choice between farming the way you are and paying $1000 per annum, and not having to pay anything and changing over to the other system, which system would you choose?'. For those conventional farmers who had indicated that they were interested in converting to sustainable agriculture under similar income conditions the question was phrased: 'Assuming that the net incomes from sustainable and conventional farming are equal, if you had the choice between the sustainable farming system and paying $1,000 per annum, and not having to pay anything and farming conventionally, which system would you choose?'. The questions were repeated for higher or lower amounts to be paid, until the point of the farmer's indifference was reached. Results are shown in Table 5.34.

The answers indicate the 'equivalent surplus' in returns to farming. 'Equivalent' because the question was phrased for all producers in such a way that the initial welfare level differed from the reference welfare level (see, for example, Pearce (1976, p.4); and 'surplus' because, due to the indivisibility of the production system, quantity adjustments by farmers when estimating their preferred position was not possible (Randall 1982, p.143). For the sustainable farmers, the answer indicated the equivalent surplus for continuing as a sustainable farmer; for the conventional producers who did not want to change under certain conditions it indicated the surplus to maintain a conventional management. For those conventional farmers who did want to change if returns were equal under the two management systems, the answer indicated the equivalent surplus of remaining sustainable farmers, the system they would have practised if the first part of the question holds.

Table 5.34: Farmers' willingness to pay for being allowed to continue with that management system which is preferred if returns from sustainable and conventional agriculture are equal

Type of Farm	Welfare Level		Willingness to Pay		
	Initial	Reference	Average ($)	Minimum ($)	Maximum ($)
Sust. all farms	S	C	11,600	1,000	30,000
Conv. all farms	S	C	4,600	0	12,500
	C	S	3,800	500	10,000

S = Sustainable C = Conventional

Note: Willingness-to-pay figures relating to the sustainable producers exclude those who preferred to leave the farm rather than farm conventionally

In answer to the first question, three fs and two ss farmers said that they would rather leave the farm than farm conventionally. One of the sustainable and two of the conventional farmers declined to answer. Averages for the other farmers are summarised in Table 5.34. Average willingness to pay of conventional farmers to stick with the system of their choice if incomes of the two systems were equal were less than half of what the sustainable farmers were willing to pay. Of course, these values reflect not only perceptions of differences in the steady state situation (as discussed in Section 5.4.3), but also expectations of the present value of transition costs, psychic costs and benefits, and long-term financial costs and benefits.

Schultze, d'Arge and Brookshire (1981) discussed four biases which can occur using hypothetical questions. Strategic bias, which occurs when the respondent gives an incorrect answer because gain is expected by doing so (the 'free-rider' problem), is not likely to apply here. This is because, at the time of the interview, sustainable agriculture was still considered to be an impractical management system by most conventional farmers. It is not likely that at that stage it had occurred to conventional farmers that, for example, subsidies might be paid to facilitate the change. Consequently, gains from a non-correct answer are not likely to have been considered by them. Gains from an incorrect answer by sustainable farmers are not immediately obvious.

Hypothetical bias increases with a decreasing degree of likelihood of occurrence of the change. It is a problem even with perfect perception of the alternatives. As all farmers asked were themselves, or knew, sustainable farmers, the possibility of using sustainable management techniques must have seemed real to all farmers. However, the ramifications of a change in management system, a second cause of hypothetical bias, might not have been fully understood by all conventional farmers.

Information bias is due to the fact that answers are based on situations not known to the interviewees. However, most of the sustainable farmers knew both management systems, so that their estimate is an ex post statement. The conventional producers were in an ex ante situation for one of the two choices. This means that the estimates of the sustainable farmers are not likely to include an information bias, while those of conventional farmers are.

Instrument bias can be due to the particular vehicle for payment, and the starting point of the bidding process. The estimate was related to the disposable income, the ideal vehicle, according to Schultze et al. (1981). The starting point of the estimate was put at $1,000. Usually, when answering that question farmers indicated whether they were willing to pay less or more than $1,000, and whether the difference between that and the farmer's willingness to pay was large. The follow-up question was what kind of payment was acceptable to them. In most cases (especially where the farmer was wiling to pay more) this question did not produce an answer, so that an outrageously high proposal was often made (such as $100,000). The answer to that question usually indicated in which area the final answer was likely to be, so that questions were centred around that amount. Although the questions asked depended on developments in the interview, the same principles were followed in each case. This should keep biases in answers between the systems to a minimum.

Answers are, of course, influenced considerably by factors such as last year's income; average savings; and present cash needs. However, since there is no reason to assume that differences between farmers in these respects are due to the management system practised (see Section 5.5), this should not lead to biases.

Some tentative conclusions can be drawn from these answers. First, psychic income from sustainable farming is perceived as considerable by practitioners of this system. To those farmers who did not practise it, but who would be sustainable producers if net financial returns of the two systems were similar, the expected psychic income from sustainable farming was lower. The amount was similar to psychic income for conventional farmers wanting to adhere to their system.

Second, sustainable farmers must assess the total returns from sustainable farming to be at least equal to those of conventional farming. The ten conventional farmers who were interested in converting to sustainable farming under certain conditions must perceive that the use of the conventional management system nets them at least $4,600 in total benefits on average per year more than the sustainable system would. Although other factors than those pertaining to the steady state situation could play a role, it seems likely that many conventional farmers are not aware that sustainable farming can be as financially rewarding as the conventional system.

5.5 Analysis of Non-Financial Issues

5.5.1 Introduction

Returns to farming depend upon many factors, including climate, soil type, quantities of inputs used, and input and output prices, and managerial skill. Some of these factors are within, others beyond the control of the farmer.

It is difficult to assess the managerial input directly, but an indication of the difference in this aspect between the two types of farmers can be gained by considering some of the demographic characteristics of the two. How old is the average farmer in each group? Is there any difference in farm experience or in formal education between the two? Is it likely that farmers of the one group have more knowledge of local farm conditions than those of the other? Another way to assess managerial input is by enquiring how farmers see themselves and their neighbours as managers. And how are their managerial skills regarded by an outside source? These issues are analysed in Section 5.5.2.

Apart from general managerial characteristics of all farmers, the analysis of some issues specific to sustainable farmers gives an insight into their performance. For example, why did they transfer from conventional to sustainable farming, and why are they continuing to farm in this way? What were the major problems when they changed, and are there any special problems at present due to the chosen production system? These issues are discussed in Section 5.5.3.

5.5.2 Assessment of managerial skill

In Table 5.35 some characteristics of all surveyed managers are displayed. The average age of sustainable and conventional farmers was similar ($p > 0.1$). The average for all sustainable farmers was 46.3 and for the conventional farmers 45.4.

Farming experience was considerable, with farmers in both groups having been in the industry for almost 30 years, on average. Experience in sustainable farming was also substantial (not shown in the table), the average for the fs group being 19.8 years, and for the ss farmers 12.4 years (no significant difference, p = 0.341). The range in experience of sustainable farm management for the fs group was from 7 to 41 years (on three of the farms no synthetic fertilisers and pesticides had ever been used), and for the ss group from 7 to 19 years.

Table 5.35: Age and years of farming experience

	Age		Years farmed			
	Years	p-value	In total	p-value	OnPresent property	p-value
Fully sustainable (fs)	47.9		28.8		23.8	
Conventional (cfs)	50.5		34.8		34.8	
Difference [8]	**-2.6**	**0.726**	**-6.0**	**0.142**	**-11.0**	**0.059 ***
Semi-sustainable (ss)	43.8		27.2		23.8	
Conventional (css)	37.2		20.8		17.8	
Difference [5]	**6.6**	**0.106**	**6.4**	**0.225**	**6.0**	**0.100**
Sust. all farmers (saf)	46.3		28.2		23.8	
Conv. all farmers (caf)	45.4		29.4		28.2	
Difference [13]	**0.9**	**0.552**	**-1.2**	**0.790**	**-4.5**	**0.308**

For symbol definition: see Table 5.3

The fs producers had farmed on the present property for a shorter time than their counterparts had on theirs. However, it seems reasonable to assume that most of the knowledge about local farming conditions is learned in the early years of farming on a particular property. For this reason dissimilarities in management skills between practitioners of the two systems due to differences in knowledge of local conditions is unlikely.

The age at which the farmer started in agriculture (age minus total number of years in farming) can be an indication of the degree of formal education a farmer has had. There was no difference between the sustainable and conventional producers for this variable (p = 0.170). A similar picture emerges from the data on formal education levels. Of the seven pairs of farmers in the fs group for whom level of education was recorded, four were educated to the same level. Two conventional farmers had completed one to four years of high school, while their counterparts had attended or completed the primary school. In one case the sustainable farmer had obtained a university degree, while his neighbour had obtained an agricultural college diploma. Of the five ss farmers, three had had the same education as their neighbours. One ss farmer had completed a few more years in high school than his counterpart. The fifth ss farmer had completed between 1 and 4 years of high school and his counterpart graduated from an agricultural college.

Management skill not only depends on characteristics acquired over time, through formal education or 'hands-on' experience, or through knowledge of local farm conditions. It is partly an inborn characteristic, difficult to quantify. Because it is such an important factor, officers of the local Department of Agriculture (DA) were asked to suggest a conventional neighbour, who was at least as good a manager as, if not better than, the sustainable farmers with whom they were compared. The officer was then asked to grade both farmers on a scale from nine to one, nine being the score for a perfect manager. In all cases but two the conventional farmer interviewed was judged to be by the officer at least as good a manager as the sustainable farmer. The two exceptions were the result of difficulties with the suitability or availability of other neighbours, and in those cases the farmers themselves did not agree with the assessment of the DA officer.

During the survey it became clear that not all sustainable farmers were known to the DA. In one such case the counterpart farmer was found by asking a farm consultant, who was based near the surveyed farms. After suspecting a bias in grading in that case (where the conventional farmer was a client of the consultant), the idea was conceived to ask farmers how they rated themselves and their neighbours as managers. The results of doing this are shown in Table 5.36

Table 5.36: Management skill as perceived by pairs of farmers

	Conventional farmers			**TOTAL F.S.**
	Equal	Self better	Self worse	
Sustainable farmers				
Equal	3	3	0	**6**
Self better	2	0	0	**2**
Self worse	0	2	0	**2**
N.A.	0	1	0	**1**
TOTAL C.F.	**5**	**6**	**0**	**11**

S.F. = Sustainable Farmers C.F. = Conventional Farmers

The majority of the sustainable farmers for whom answers were recorded (six of the eleven) felt they were equally good managers as their counterparts, while six conventional farmers thought that they were better themselves. Only three of the conventional farmers agreed with the sustainable farmers that they had similar managerial skills. Two of the sustainable farmers considered themselves to be superior managers to their counterpart (with which their counterparts did not agree), while two thought their management skills were less (with which their counterparts did agree). For most of these cases the differences were minimal; that is, one point.

On average, the sustainable farmers considered themselves similar to the conventional farmers (p = 1.000), with an average score for the sustainable and conventional farmers of 6.7 and 6.6 points, respectively.

The conventional farmers, on average, felt that they were better (p = 0.036) with average scores of 5.8 and 6.5 points for the sustainable and conventional farms, respectively.

Also in the estimation of the Department of Agricultural officers, the differences were usually not large. There were three exceptions, where the sustainable farmers scored four points less than the conventional farmers. One of those cases involved the farm consultant mentioned above, whose impartiality may be queried. In the other two cases, however, a difference in management must be considered likely. The average score by the DA officer for the conventional farmer was higher than for the sustainable farmers (7.0 and 5.7, respectively) (p = 0.076). If the pair graded by the farm consultant was excluded, no significant difference is recorded (p = 0.142).

In summary, it is likely that most conventional farmers were at least as good managers as their sustainable counterparts. However, it is quite possible that at least two conventional farmers were far better managers than their sustainable farmer neighbours.

5.5.3 Issues specific to sustainable farmers

5.5.3.1 Motives for sustainable farming

It is easy to appreciate that a technology in which synthetic fertilisers and pesticides were used to combat problems with soil fertility and pests was very attractive to farmers, and was readily adopted. Only a few producers never adopted that technology or, having adopted it, converted back to a form of agriculture not obviously superior to conventional agriculture. So the question was asked: 'Why did you change from conventional to sustainable farming, and why are you still farming like that at present?'. The answers are presented in Table 5.37 under A.

Farmers were asked to rank the reasons given, so that a degree of importance could be gauged. As the maximum number of reasons given was six, the top ranking reason was assigned the value six, the next most important five, et cetera. The sum of the values for each reason are recorded under B in Table 5.37.

Table 5.37: Reasons for using sustainable farming practices at stage of conversion and at time of interview

	Initial		At interview	
	A %	B %	A %	B %
Health of soil	32	37	29	35
Health of farm crop/stock	19	19	14	15
Health of farmer/family	10	9	9	9
Environmental concern	13	11	9	8
Increased personal involvement with management	3	3	6	7
Religion	6	6	6	6
Decrease of production costs	6	7	14	12
Output premiums	0	0	6	3
Other	10	7	9	6
	Number of answers			
TOTAL	31	148	35	159

A = Number of answers for a particular reason divided by total number of answers

B = Total of answers times values as indicated by farmers (see text) divided by the sum of all values

On 3 of the 13 sustainable farms fertilisers and pesticides had never been used. Of these 3 farmers, 2 had never changed from conventional to sustainable farming. Questions about conversion were not asked. The third farmer bought the farm in 1973. His reasons for using sustainable practices on this farm are included.

Of the 11 farmers who mentioned their motives for using sustainable farming practices, 10 indicated that the state of the soil was an important aspect in the original decision to change production system. Three farmers mentioned that they had 'nothing to lose' by changing over. Two of these 3 said that they would have had to leave the farm due to problems with soil, crops and stock, if they had continued with conventional farming. The health of farm crops and stock is closely related to the health of the soil. These three reasons together accounted for more than half of the total answers, and also of the total values.

Other reasons included health of the farmer or the farmer's family; concern about the environment beyond the farm; increased personal involvement with farming as compared to the conventional system; and religion. Although only two farmers mentioned this last reason specifically, several more indicated during the interview that religion was important in their lives. From the interviews with the two types of farmers the impression was gained, although not captured in figures, that for many sustainable farmers reasons other than private financial benefits (such as the teachings of the bible) were important in the original decision to convert.

Reasons related to short-term financial considerations, such as decreased production costs and premiums for outputs, were not prominent on the list at the conversion stage. This situation changed over time.

At the time of the interview, the most important reasons for farmers to continue practising sustainable agriculture still were concern for farm crops, stock and soil. However, in relative terms these reasons decreased slightly in importance (43 per cent of total responses and 50 per cent of the total of values). This was due mainly to the increased importance of the effect of the farming system on production costs, output premiums and degree of personal involvement.

The increased importance of production costs and output prices of the two systems could be an indication of changing times. When profit-maximisation is the only determinant of a farmer's behaviour, cutting input costs and collecting premiums for outputs are important factors of consideration. If profit-maximisation is not the only consideration (for example, when considerations of lifestyle are included in the production process, as is likely to be the case with sustainable farmers (see Section 5.4.4)), input and output prices may be of less importance. However, especially in times of generally increasing farm costs and decreasing output prices, low input and high output prices may assume an increasingly important role also in such a case. Another explanation of the increase in importance of these aspects is that, although these consequences of practising sustainable agriculture were not the reason for the conversion (or, indeed, might not have been obvious at that time), they were appreciated once the change was made. It is likely that premium prices did not exist at the time when most farmers converted.

Lockeretz and Wernick (1980, p.710-11) also found that concern for health of livestock (32 per cent), soil (30 per cent), and human beings (22 per cent) were important reasons for adopting organic farming methods in the USA (many respondents gave multiple reasons for converting). Other specific problems mentioned included cost of chemicals (25 per cent) and ineffectiveness of chemicals (23 per cent). In total 75 per cent of the respondents indicated that at least one specific problem or concern contributed to the decision to convert to organic farming. Contact with proponents of organic farming were mentioned in 48 per cent of the cases, and ideological concerns in 34 per cent.

Lockeretz and Madden (1987), in a 1987 follow-up postal survey of 174 commercial farmers first conducted in 1977, found that the four single most important reasons for farming organically were the health of farmer and family (60 per cent), health of livestock (40 per cent), environment (37 per cent) and soil considerations (31 per cent) (each farmer could indicate 3 items as leading advantages for farming organically). These were also four of the five major reasons named in 1977. Philosophical/ religious reasons, which were major in 1977 were less important in 1987.

Conacher and Conacher report (1982, p.10) that, of the 144 answers on reasons for converting at the time of the initial decision, 36 indicated 'detrimental effects of synthetic chemicals', 31 philosophical factors, 25 decline of soil fertility, 18 pollution of water and soils, and 15 costs of fuel, fertilisers and biocides. Although some of these categories overlap, it is clear that problems caused by synthetic fertilisers and pesticides were major reasons for conversion. Reasons for continuing farming organically at the time of writing were similar to those at time of conversion.

5.5.3.2 Problems of sustainable farming

Because so few producers use sustainable farming techniques, special problems can be expected for those who farm in this way.

Farmers were asked about the main problems of sustainable farming at the time of conversion, and at the time of the interview. In Table 5.38 the answers are recorded for the number of times each was mentioned (column A). This was multiplied by a figure indicating the degree of importance of the difficulty, as experienced by the farmer (column B). As the maximum number of problems referred to was five, the most important was assigned the number five, the next most important four, *et cetera*.

Of the seven categories mentioned, lack of availability of information, and weeds in the crops were seen as the major problems at the time of conversion. This was the case both in terms of number of times they were mentioned (28 and 24 per cent respectively) and in terms of degree of importance attached to them (over 30 per cent each). However, it should be borne in mind that the list is not mutually exclusive. Lack of information is, of course, lack of information about certain aspects of farming, and it is likely that problems with weeds, availability of inputs and cash flow are amongst the aspects for which information was felt to be lacking. If 'information' is excluded from the list, weeds are mentioned in over 30 per cent of the cases, constituting over 40 per cent of the total value attached to the different problems.

In the category 'other' two issues stand out. One is the perception that timeliness of operations was of the utmost importance, more so than in conventional agriculture. This characteristic was best described by a conventional farmer who volunteered a philosophical assessment of the advantages and disadvantages of sustainable agriculture. In his opinion sustainable farmers '...had to be much more accurate in their timing of operations than conventional farmers. If conventional farmers slip up on some operations like weed control, they usually still can do something about it next week with weedicides. For sustainable farmers, if they are a week late with weed control, they might not be very effective anymore. They will suffer for that mistake the rest of the season. They will have to wait for another year to do it right.'

Table 5.38: Main problems of sustainable farmers at the conversion stage and at time of interview

	Initial		At interview	
	A %	B %	A %	B %
Information	28	31	27	32
Weeds	24	31	27	32
Availability of inputs	17	13	12	8
Marketing	0	0	8	6
Cash flow	3	5	0	0
Social pressure	10	7	8	6
Other	17	13	19	14
	Number of answers			
TOTAL	29	86	26	77

For symbol explanations: see Table 5.37

The second issue pertains to isolation. Two sustainable farmers remarked that they knew no other farmers with whom they could discuss their practices. One described it as 'battling on your own all the time'. Although this aspect of sustainable farming was mentioned specifically as a problem by only two farmers, several other farmers referred to it during the interview. To the question whether they knew any other sustainable farmers, many answered in the negative or referred to somebody they did not know personally. When asked who were their main sources of information on sustainable agriculture only six farmers mentioned 'other farmers' (see Section 5.5.3.3). This would indicate that more than half of the 13 sustainable farmers either had no contact with other sustainable farmers or did not feel that they were getting any information from that source.

Two other problems mentioned were lack of interest from government departments in sustainable agriculture and lack of availability of technology. In other words, it was felt by two sustainable farmers, that solutions to problems could be found within the concept of sustainable farming, but that no efforts were made by relevant authorities to find solutions within that technology.

Another aspect of sustainable farming commented upon by several farmers, but mentioned specifically as a problem by only one, was what this sustainable farmer described as 'an increasing anxiety about sitting back and seeing what happens'. This farmer talked about the psychological problem of seeing weeds in crops, without being able to revert to sprays. It took several seasons to get used to the idea that some weeds in the crop might not be so bad and could, in the end, be better than using sprays.

Weeds and lack of information remained a large problem. At the time of the interview, availability of inputs, cash flow and social pressure were the only difficulties which had diminished both in absolute and in relative terms. Marketing was not mentioned at the initial stage, but was seen at the interview as a problem by two farmers.

Conacher and Conacher (1982, p.26) reported that, of the 50 respondents in their sample, 29 mentioned lack of advice/information as a problem, 21 lack of availability/ costs of organic material, 18 pest control, 15 weed control, 13 maintaining/ improving soil fertility, 13 marketing, and 11 labour (other problems were mentioned by fewer than ten farmers each).

Respondents in the survey by Lockeretz and Madden (1988) considered location of organic markets the main problem, both in 1977 (38 per cent) and 1987 (40 per cent). It was closely followed in importance by weed problems (39 per cent in 1987). Difficulties in obtaining information were regarded considerably less important (just over 20 per cent). This may indicate a difference in availability of information about sustainable agriculture in Australia and the USA.

5.5.3.3 Information about sustainable farming

As it is likely that most of the resources for agricultural research are committed to the dominant kind of agriculture, where do practising and prospective sustainable farmers acquire information about the system? In Table 5.39 the sources mentioned by the sustainable farmers are listed.

Table 5.39: Information sources for sustainable agriculture at conversion stage and at time of interview

	Initial		At interview	
	A %	B %	A %	B %
Books	33	34	26	29
Trial and error (self)	15	18	23	24
Farm newspapers	11	9	14	12
Other farmers	7	7	17	15
Consultants	7	8	3	3
Department of Agriculture	4	3	3	3
Conferences/ seminars / field days	4	1	6	4
Other	19	19	11	11
	Number of answers			
TOTAL	27	108	35	136

For symbol explanation: see Table 5.37

Nine of the 11 farmers indicated that, in the initial stage of transition, most of the information was gained from books. Four indicated that they found their way by trial and error, which sometimes involved having small experimental plots of different crops or different treatments on their farm. Farm newspapers were generally overseas newspapers, specifically directed towards sustainable agriculture.

'Other farmers' and consultants (mainly of importance in one State) were relatively unimportant as a source of information in the initial stages. Their degree of importance, however, changes over time. 'Other farmers' become more important as a source of information over the years, while consultants become less so.

The Department of Agriculture, conferences, seminars and field days, although mentioned, were not prominent on the list either for number of times consulted, or for the importance attached to the contact.

'Other' included religious literature, and in one case the farmer's father, who could be considered the developer of bio-dynamic agriculture in Australia.

Not surprisingly, information from books becomes less important, while trials and observations on the farm become more so. Together, these two sources still made up half of all sources from which information was gained at the time of the interview. Two other sources of up-to-date information also increased in importance: papers and other farmers.

The conventional farmers were also asked where they acquired their information about farming. All but one mentioned the Department of Agriculture as a source, 12 mentioned rural papers and magazines, nine mentioned conversations with 'other farmers', and eight attending field days. Stock agents and input representatives were mentioned by eight, and farm consultants by two. Only one farmer mentioned that he did some trials himself. As can be expected, the Department of Agriculture and 'other farmers' were much more important sources of information for the conventional than for the sustainable farmers. No conventional farmer mentioned books as a source of information, a source of considerable importance to sustainable farmers.

One source of information on agricultural practices, the Department of Agriculture, was asked how information was provided to sustainable farmers. Six officers were asked the question: 'What would you say if a farmer walked in here and said: "I don't want to use synthetic fertilisers and pesticides any more. How do I go about it?"'. Three of the four officers who had been contacted in connection with fs farmers answered that they would send the farmer to the sustainable farmer (one, who had visited the sustainable farmer previously, said that he would accompany the conventional farmer). The fourth officer would tell the farmer that '...he is mad to have his crop eaten by army worms'. He said that he would refer the farmer to literature, although he was unable, even after lengthy prodding, to specify even one magazine or book considered suitable by him. The two DA officers who knew three ss farmers would both discuss extensively with the conventional farmers why they wanted to stop using agricultural chemicals. One said that after such a discussion he would point out: 'Most people who want to control weeds without chemicals control them by wishful thinking'. The second officer said that he would inform the farmer that: 'We don't look into alternatives here'.

In summary, information on sustainable agriculture comes overwhelmingly from unofficial sources: books, newspapers, own and other farmers' experiences. Official channels of information such as the Department of Agriculture, conferences, seminars and field days are not considered by sustainable farmers to be useful. At the time of the interview, officials in the Department of Agriculture who are responsible for the dissemination of information on agriculture did not see it as their task to supply (prospective) sustainable farmers with information relevant to that way of farming.

5.6 Summary and Conclusions

In a survey with so few participants statistical inference is not easy to apply. Although statistically significant differences between the samples were not always established where they were expected, a picture can be formed of sustainable farming as practised at present by cereal/ livestock producers in south-eastern Australia.

The first conclusion is that the average net financial results of producers who farm without the use of synthetic fertilisers and pesticides can not be seen to be different from those obtained on comparable conventional farms in 1985-86.

The sustainable farms were in areas with similar climate and soil quality (as measured by improved capital value per hectare) to that of their conventional counterparts. The use of less fertilisers per cropped unit of land on sustainable farms is therefore not due to the intrinsic quality of the land, but to a conscious decision to adopt an approach to farming very different from the conventional production system. The fact that some farmers tending towards sustainable practices, especially those in relatively marginal cropping areas, were still using some synthetic fertilisers indicates that not all problems have been solved regarding soil fertility and alternatives to conventional inputs.

Several methods were used by sustainable farmers to prevent loss of soil fertility. First, the percentage of arable area cropped was kept down. On average the fs farmers cropped less than half of the arable area, while the cfs farmers cropped more than three quarters. All of the fs farmers cropped less than their conventional counterparts. This was not true for the ss producers, whose cropping percentages were, on average, much closer to those of their conventional counterparts.

Soil fertility was also maintained by the use of animals. However, no statistically significant differences in number of livestock were recorded between the two systems per hectare grazed.

A third possible method of maintaining soil fertility is by diversifying crops. Although no statistical differences in number of crops were recorded, the percentage of cropped area in wheat was lower on sustainable than on conventional farms.

Most of these management tools (levels of cropping and stocking, and diversification of cropping) can be used not only to solve soil fertility problems, but also in the battle against pests. With regard to mechanical pest management, differences in cultivation practices were not immediately obvious from figures on fuel costs per hectare cropped. Also timing of cultivation was similar in the two systems, although sustainable farmers tended more towards the use of tined implements.

The differences in management practices did not lead to significant differences in yields. However, the sustainable farmers did obtain lower receipts from cropping per hectare operated. This was due to a smaller cropped area as a percentage of arable area. These lower receipts are at least partly compensated for by lower input costs of fertilisers, pesticides, and especially machinery and equipment.

Receipts from livestock per hectare operated were similar under the two management systems, for those pairs of farmers where both kept stock. When all eight fs and cfs farmers are included a difference can be shown for this variable.

Overall, the total cash costs of sustainable farming were significantly lower than those of conventional farming. Total cash receipts, though not different between the two systems for the fs-cfs and ss-css farmers separately, was higher for the conventional farmers if all 13 farmers were pooled. The bottom line, return to capital and management adjusted for interest and rent, was that a difference between the two systems could not be shown statistically.

Apart from indications of differences between sustainable and conventional farmers, a picture of differences between the fs and ss group of farmers emerged. The css farmers, although selected in the same way as the cfs producers, showed some characteristics distinct from those encountered amongst the cfs farmers. On average, the pattern of inputs for the css farmers indicates that it is likely that they farm in more marginal areas than cfs producers (for example, relatively low land prices), where cropping is relatively extensive (for example, relatively low use per hectare cropped of pesticides, fuel, machinery and equipment, and labour).

The question could be asked whether there is a causal relationship between the degree of adoption of sustainable farming and the degree of marginality of the area. If a relationship could be established, the question arises whether the reasons for such a relationship are agronomic problems, or whether they are different in nature. For example, in marginal cropping areas the area in crop per farm is relatively large, with low returns per hectare. Although input costs per hectare are also low, total expenditure on inputs per average farm is relatively high. This could imply that higher risks are taken by sustainable farmers in marginal areas than by those in non-marginal area when adopting a management system about which little information is available. It is only when the cause of a relationship between the degree of acceptability of the sustainable system and the degree of the area's suitability for cropping is established, that a beginning can be made with answering the question about the limits of sustainable agriculture.

It is unlikely that differences between practitioners of the two systems in formal and informal education, experience, and knowledge of local conditions influenced the relative financial returns of the two types of farming. Likely differences in management skills between some pairs of farmers probably depressed average returns on sustainable farms. It is also likely that lack of information about sustainable farming negatively influenced the financial returns from this type of farm system.

In summary, the results from the survey indicate that net private financial benefits from sustainable farming were similar to those in the conventional sector in certain areas in 1985-86. This was the case despite lack of information about the sustainable management system, and despite the fact that some conventional farmers were likely to be better managers than their sustainable farmer counterparts.

6 A COMPARISON OF LONG-TERM CROP YIELDS ON SUSTAINABLE AND CONVENTIONAL FARMS

6.1 Introduction

Crop yields depend on a number of factors, most of which were mentioned in Chapter 5. Within a particular management system many of these factors, such as soil type, managerial skill, fertiliser and pesticide applications, and machinery inputs change very little in the short-term. Fluctuations in yields over time are therefore due mainly to yearly variations in weather.

In Chapter 5 crop yields were discussed for one year only, 1985-86. For that year the average wheat yield for the two systems was shown to be similar. However, it is possible that this was an exceptional year, in which weather affected crops on the two types of farms in an uncharacteristic way. In order to obtain some insight into this matter, historical yield data were collected from as many of the pairs of farms in the survey (see Chapter 5) as possible. Three types of analyses are carried out on these data: static, time trend, and variability.

The static analysis involves testing for yield differences between the two management systems in individual years. With this analysis it can be determined whether differences in yield should be expected, and if so, in which direction and how frequently (Section 6.2.1).

The second type of analysis, which involves examining changes in yield over time for the two farming systems (Section 6.2.2), is of interest especially in connection with two issues. One, at present it is generally assumed that a decrease in yield in the transition period from conventional to sustainable farming is probable (see Section 5.3.1). Two, it is widely assumed by practitioners of conventional agriculture that, although yields on sustainable farms might benefit from the period under conventional management just after transition, yields will ultimately drop on these farms.

Differences in variability of crop yields are mentioned in some of the literature about sustainable farming (Klepper et al. 1977; Conacher and Conacher 1982). The reasons for lower yield variability on sustainable farms (also mentioned in earlier chapters) are twofold. One, crops grown under the conventional system perform well under optimal conditions. In good years, higher yields can be expected on conventional than on sustainable farms. On the other hand, in adverse weather conditions yields may not suffer as much on sustainable as on conventional farms. One of the explanations is that, with a relatively high organic matter content in the soil on sustainable farms, crops are subject to drought stress later than on conventional farms. However, in extreme conditions, such as severe droughts, the effect would of course not be notable. In Section 6.2.3 this aspect of the two systems is examined.

Apart from analysing actual yield differences, it was considered of interest to note farmers' perceptions of the relative yields of farms under different management systems. The question: 'How much do you estimate the difference in wheat yield to be between the two systems in an average year?' was designed partly as a check on the yield figures provided by farmers, in addition to explaining unexpected variations. However, during the interviews the impression was gained that most yield figures supplied were likely to be quite accurate. At the same time, answers to the question on the relative yields seemed less related to actual yield differences between the two farm types than to the management system practised by the interviewee. These answers may therefore be of interest for reasons unrelated to verification of actual yields, such as for decision making about the direction of extension programs. This issue is discussed in Section 6.3.

6.2 Actual Yields

6.2.1 Yields in individual years

Average wheat yields in individual years for the sustainable and conventional farms are shown in Tables 6.1 and 6.2. In Table 6.1 yields are shown for the fully sustainable growers and their conventional farmer counterparts (fs and cfs), while Table 6.2 gives yields for all sustainable producers and their conventional farmer counterparts (saf and caf). For the semi-sustainable and their conventional counterparts (cs and css group), not enough pairs of farmers could be included to warrant a separate table.

Table 6.1: Comparative wheat yields on fs and cfs farms

Year	Pairs of farmers	Sust. farmers	Conv. farmers	Sust. - Conv.		
	No.	t/ha	t/ha	t/ha	p-value	%#
1979-80	3	1.8	2.5	-0.70	0.181	-28
1980-81	4	1.0	1.7	-0.68	0.100*	-40
1981-82	4	1.8	2.4	-0.63	0.361	-26
1982-83	4	0.5	0.3	0.18	0.789	60
1983-84	5	2.9	2.9	0.06	1.000	2
1984-85	5	2.4	2.2	0.20	0.787	9
1985-86	7	2.4	2.5	-0.13	0.673	- 5
1986-87	7	1.8	2.4	-0.61	0.151	-25
1987-88	7	1.5	2.4	-0.90	0.173	-38

* = significantly different at the 90 per cent confidence level, tested with the Wilcoxon-test
\# = sustainable minus conventional yield divided by conventional yield

Of the eight pairs of fs-cfs farmers, one cfs farmer did not grow wheat (see Section 5.4.2.1). It is for this reason that the maximum numbers of pairs shown is seven.

For the sustainable farmers data were used only if the farmer had grown crops under the sustainable system for at least five years. This was done to eliminate the biggest part of the possible negative transition effect on yield (see Section 5.3.1).

Although 1982-83 is included in the table, a word of warning is needed. This year was one of severe drought. Many farmers did not sow or, having sown, did not harvest their crops. Yield figures could well be related to harvested areas, while for other years they relate to total area in the crop under consideration.

The method employed to examine whether the yields were different in the two systems is the Wilcoxon test, which is explained in Section 5.3.3.

For the analysis, those years are counted where only three or more pairs are included in the average yield figures. For at least half of the years included the number of observations is very low. In such cases the Wilcoxon-test is not very sensitive to departures from the hypothesis that the yields are the same. The figures should therefore be regarded as an indication.

In five of the nine years the wheat yields on sustainable farms were 20 percent or more lower than on the conventional farms. However, only in one year (1980-81) was this significant in a statistical sense ($p = 0.1$).

Another way to examine differences between means is with the aid of a Sign-test. If there is no difference between yields in the two systems there is a 50 per cent probability that either system records the best yield each year, and these are independent from one another. To test whether this was the case over the period 1979-80 to 1987-88, a Sign-test was carried out. With this test, the probability of the observed signs is calculated assuming no difference between the yields. The test was applied to the difference in yield as a percentage of the yield on the conventional farms (Table 6.1, last column), and recorded no difference between the two systems ($p = 0.508$; two-tailed test).

If all farmers are included (Table 6.2), the maximum number of pairs of farmers is ten. This is because, in addition to the cfs who did not grow wheat, two pairs of ss-css farmers grew barley as their main crop, so that they did not have historical yields for wheat. Because it is not clear whether sustainable and conventional agriculture affect relative yields differently for different crops, it was considered inappropriate to include these crops in the analysis.

Table 6.2: Comparative wheat yields on saf and caf farms

Year	Pairs of farmers	Sust. farmers	Conv. farmers	Sust. - Conv.		
	No.	t/ha	t/ha	t/ha	p-value	%#
1979-80	3	1.8	2.5	-0.70	0.181	-28
1980-81	4	1.0	1.7	-0.68	0.100*	-40
1981-82	4	1.8	2.4	-0.63	0.361	-26
1982-83	4	0.5	0.3	0.18	0.789	60
1983-84	6	2.8	2.8	0.05	1.000	2
1984-85	8	1.7	1.8	-0.10	0.624	- 6
1985-86	10	2.0	2.3	-0.30	0.185	-13
1986-87	9	1.6	2.1	-0.54	0.124	-26
1987-88	9	1.4	2.2	-0.78	0.161	-35

* = significantly different at the 90 per cent confidence level, tested with the Wilcoxon-test
# = sustainable minus conventional yield divided by conventional yield

For one of the nine years a statistical difference was established between the saf and caf wheat yields (p = 0.1). A Sign-test based on the differences over the nine years resulted in a p-value of 0.180 (two-tailed test).

In summary, in none of the years 1979-80 to 1987-88 are the average wheat yields on sustainable farms shown to be significantly lower than on conventional farms. It should be remembered, however, that in at least half of the years included, the number of observations is very low so that departures from the hypothesis that the yields are the same are difficult to detect.

6.2.2 Yield trends

From five pairs of farmers in the survey, enough data were obtained to analyse yield changes over time. These should be considered as case studies. Two of these were ss farmers, of whom one grew barley as the main crop.

There are two main requirements for the appropriate application of Student-t tests to detect trend differences between two series of data. The first is the existence of a normal distribution of the differences, and the second is absence of auto-correlation (dependence between errors) of the differences. After examining the data, it was decided that it could not be assumed that these two requirements were met, so that a sophisticated statistical analysis was not warranted. For this reason the data are presented here in plot form (see Figures 6.1 to 6.6), allowing visual examination of the differences between farms.

In many areas there exist differences in rainfall, both in quantity and timing, between farms in any one year. If these differences are random, this should balance out for the two farms, so that neither is disadvantaged in the long run. One way to deal with a situation where any particular year might not provide a good picture of the crop yield potential is to employ a moving average. Although the use of such a method does have the advantage of smoothing the series, so that existing trends in the data can be detected more readily, there is the disadvantage that less observations are available. Especially where not many are obtainable, as in the present case, this can be a considerable drawback. It is for this reason that the moving average of only three years is employed here.

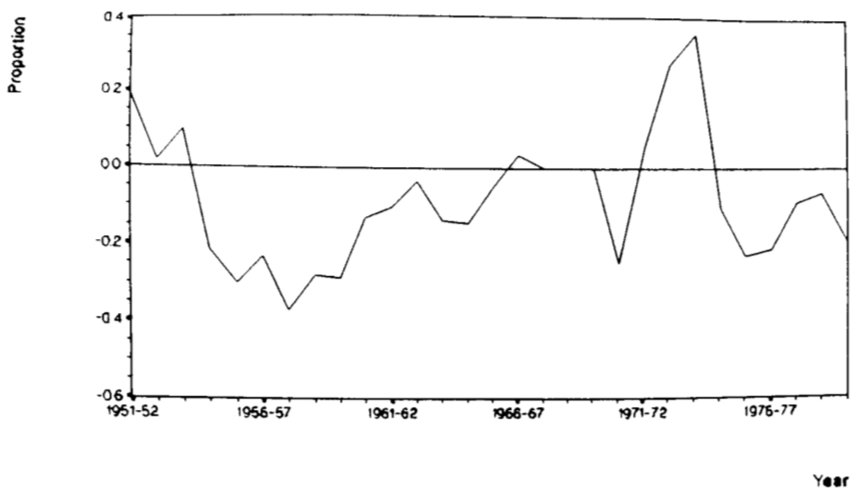
Figures 6.1 to 6.6 indicate the difference between yields of the two systems. In the plots, the years are shown on the horizontal axis as the middle year of the three-year moving average. The relative differences of production per hectare are indicated on the vertical axis (yield on the sustainable farm minus that on the conventional farm as a proportion of the conventional yield). The interest of the figures is the change in the differences between the yields of the two farms, and not the differences per se. For example, constant yield differences would indicate differences between the two farms of factors which do not change over the time period under consideration, such as the total yearly rainfall or rainfall pattern, soil type, and aspects of managerial skill. For some sustainable farmers this yield difference was significantly higher (for example, for pair number 4, $p < 0.1$). For others a significantly lower value was recorded (for example, for pair number 1; $p < 0.1$)). To establish differences in trends over time, the change in the difference must be considered.

Although a negative effect on yield is expected in the first years after transition, it is not clear for how many years this is likely to continue. Indeed, it is possible that the time period in which this effect manifests itself is dependent on a combination of factors such as past fertiliser and pesticide applications; crop rotations adopted in the past and at present; and climatic conditions. It was hoped that answers to a question about this aspect of transition in the questionnaire would clarify the situation somewhat for Australian conditions. However, the answers were too diverse to enable firm conclusions (see Section 6.3.2).

For the period before the transition, only one set of data was available (pair 1; Figure 6.1). In fact, the figures for the conventional farmer are not those of the neighbour, but are shire averages. The fs farmer was one of the three, mentioned in Section 5.5.3.1, who said that he had no choice but to change his approach to farming radically, if he were to survive as a farmer. Declining yields were mentioned specifically in this connection. Figure 6.1 confirms this picture.

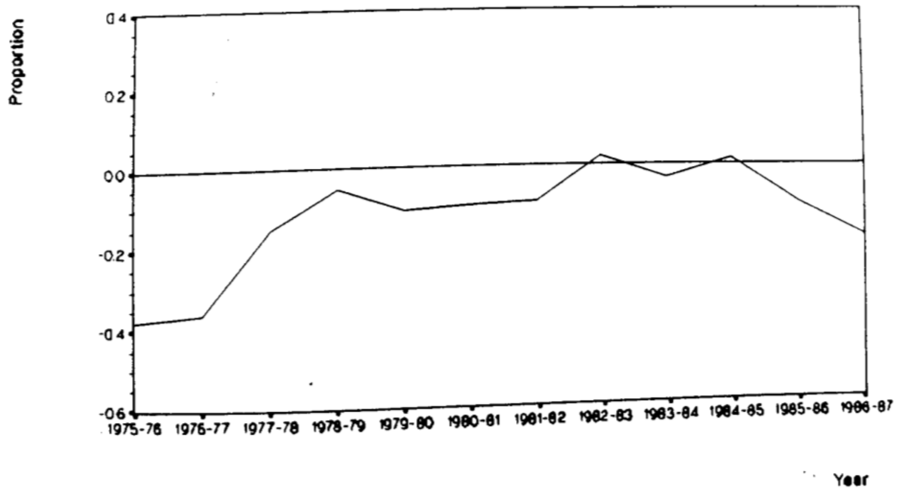
During the transition (which took place in 1963), decreases in yield on this farm are not obvious relative to the shire averages, although the farmer reported that yields did not catch up with those of his neighbours for another 14 years. From 1974-75 comparison with the neighbour is possible (Figure 6.2). Apart from the two observations at the end of the series, the yield on the sustainable farm did increase as compared to that on the conventional farm. From year 13, 14 and 15 after conversion (the observation corresponding to 1977-78 in Figure 6.2), differences are between -20 and 0 per cent and mainly diminishing for the following 8 observations. The last two points do not fit the trend, and are unexplained. However, in the last year of observation unfavourable conditions after planting was a major cause of relatively low yield.

Figure 6.1; Yield Differences Farm No. 1 and Shire



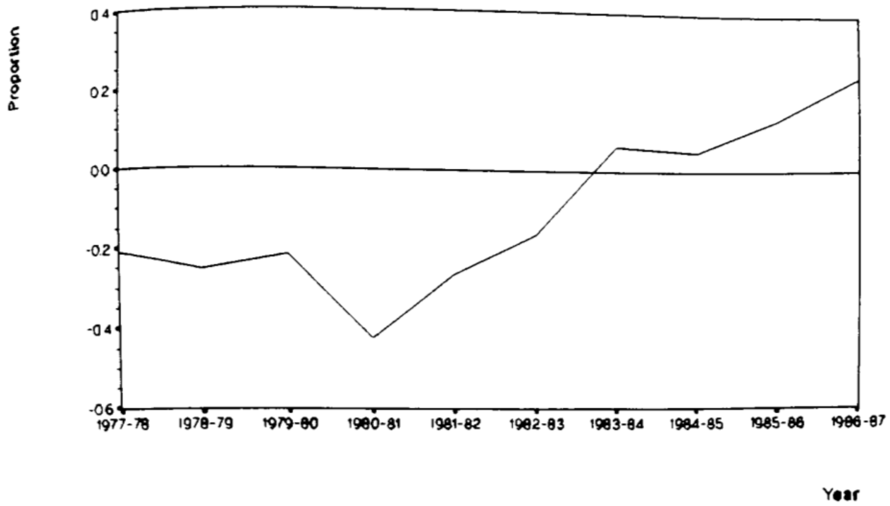
Three year moving average of difference between sustainable and conventional yield as a proportion of conventional yield.

Figure 6.2: Yield Differences Farm No. 1



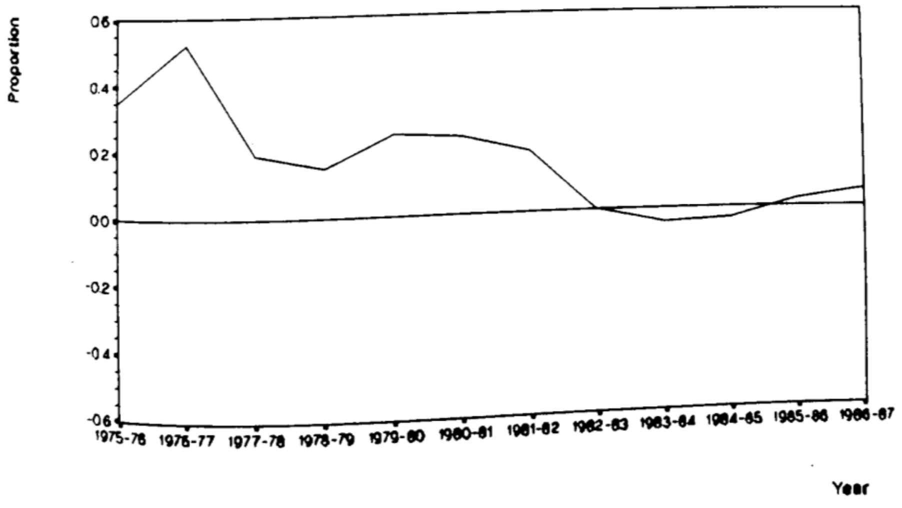
Three-year moving average of difference between sustainable and conventional yields as proportion of conventional yield.

Figure 6.3: Yield Differences Farm No. 2



Three-year moving average of difference between sustainable and conventional yields as proportion of conventional yield.

Figure 6.4: Yield Differences Farm No. 3



Three-year moving average of difference between sustainable and conventional yields as proportion of conventional yield.

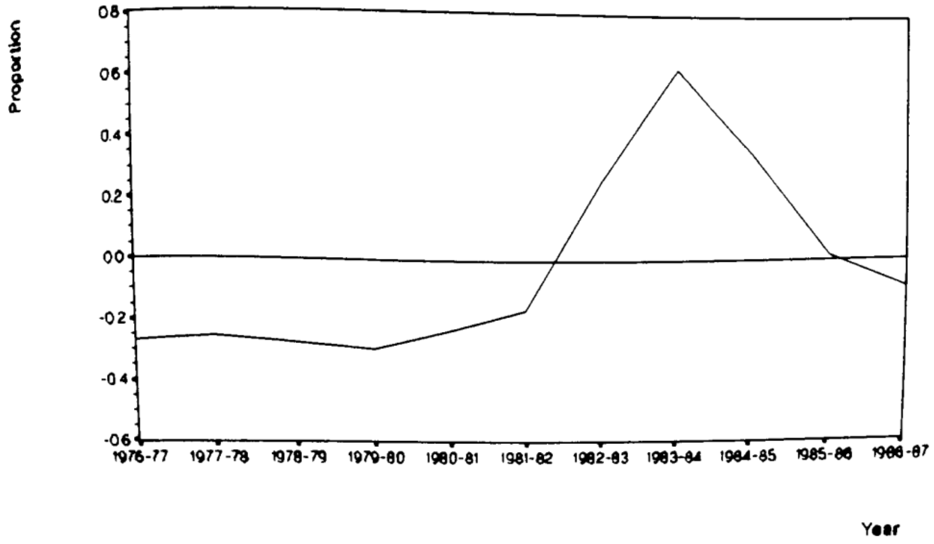
The fs farmer of pair 2 (Figure 6.3) had bought the farm in 1972. This property had previously not had any application of synthetic fertilisers and pesticides, but other sustainable practices had not been included in the management. In such a situation it is likely that, after the introduction of a sustainable management system, a biological balance was established in shorter time than on a farm where conventional farming had been practised. Since the conventional neighbour could supply yield figures only from 1976-77 onwards, the comparison is from that year to 1987-88. The result is somewhat striking. The period under consideration could be considered as an 'after transition' period, on the grounds that the establishment of a biological soil balance did not require many years. On the other hand, the farmer might have needed some time to develop a managerial system suited to the area. Whatever was the case, over the years the wheat yield on the sustainable farm mainly increased relative to that on the conventional farm.

The series for pair number 3 are the only ones relating to barley. The ss farmer converted in 1971. The first year recorded is 1974-75 (Figure 6.4). Although the yield of the ss farmer decreases relative to the neighbour after an initial rise, this is not the only period in which it drops, indicating that the transition might not be the reason for the decrease.

The fs farmer in pair number 4 (Figure 6.5) converted in 1974, just before the series commences. His estimate that yields decreased relative to what he could have obtained under conventional management seems to be borne out. However, the estimate of the duration of that period ('approximately ten years') could be queried. The last two observations show a lower yield for the sustainable relative to the conventional farmer, although not as low as in the transition period.

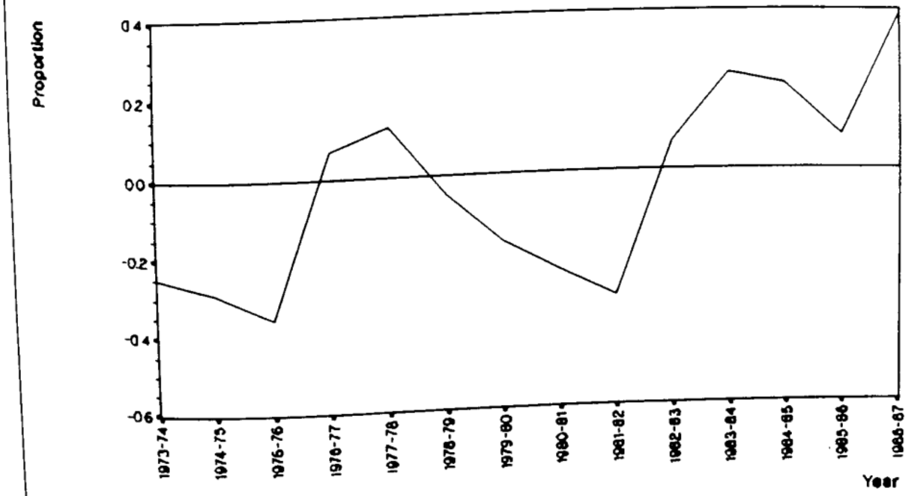
Differences in yield between the two farmers of pair number 5 (Figure 6.6) seem rather variable. The two farms were located approximately 20 km apart in an area where rainfall could be very patchy. However, both farmers estimated average annual rainfall to be similar for the two farms. The ss farmer opined that no decrease in yield was experienced due to the transition to the sustainable system (in 1979-80), which seems plausible since there are no signs of prolonged relatively poor yields in that

Figure 6.5: Yield Differences Farm No. 4



Three-year moving average of difference between sustainable and conventional yields as proportion of conventional yield.

Figure 6.6: Yield Differences Farm No. 5



Three-year moving average of difference between sustainable and conventional yields as proportion of conventional yield.

period. Although few observations are available for the 'after transition' period, an increase in yield of the ss farm as compared to the css farm should be considered a possibility.

In summary, the picture of relative yields on conventional and sustainable farms in the transition period is not clear. Although decreases on sustainable farms seem to have occurred after transition in two of the four cases where wheat was grown (farms 1 and 4), in the other two cases (farms 2 and 5) this was not obvious. In the only case where barley was grown (farm 3) the decrease was not obviously due to the transition.

Differences in yield trends after transition are easier to detect. From the graphs, an indication is gained of increasing yields on sustainable farms as compared to those on conventional farms in four of the five comparisons. On the fifth farm, the only farm where barley yields were analysed (farm 3), the trend is reversed.

6.2.3 Yield variability

If the hypothesis that crops on sustainable farms suffer less from dry conditions than on conventional farms is correct, then yields on sustainable farms would be high relative to those on conventional farms in dry years.

In Figures 6.7 to 6.13 the standardised yield on the conventional farm is shown on the horizontal axis. This is the yield on the conventional farm expressed in percentages of the highest yield achieved on that farm. This is plotted against, on the vertical axis, the yield on the sustainable farm relative to that on the conventional counterpart farm (that is, yield on the sustainable divided by that on the conventional farm in a particular year). Perfect correlation of yields in the two management systems would result in a horizontal line at 1.0. A downward sloping curve would be consistent with the hypothesis of high yields on the sustainable farm relative to that on the conventional farm (vertical axis) in years of low yields on conventional farms (horizontal axis). If the climatic conditions become too severe, as in the case of a drought, crops are not viable in either system. A cut-off point in yields, below which level differences are not present, should therefore be expected.

Figures 6.7 to 6.11 represent these data for five farmers. These are the same growers as those considered in Section 6.2.2. Data are taken from the sixth year after transition, to exclude possible negative effects in that period of farming (see above). The year 1982 was excluded, since this was a year of major drought for most farmers.

In none of the figures is the picture very clear, although in most a downward sloping trend seems apparent. This is the case especially for farmers 2, 3 and 4 (Figures 6.8, 6.9 and 6.10). The soil on the ss farm of pair 5 was sandy as opposed to a clay soil on the conventional farm. As water holding capacity of the soil is closely related to the type of soil, the difference in soil type makes comparison of the two farms for this variable virtually meaningless.

At an aggregate level the trend might be easier to detect. In order to examine this, the data of the sustainable farmers were combined in one series, and those of the conventional counterparts in another. The data for pair 5 were not included. The results are shown in Figure 6.12.

Regression analysis can be employed to detect a relationship between the yield on sustainable farms relative to that on conventional farms, and the yield on conventional farms.

A linear relationship can be expressed as:

$$y = a + bx$$

and a quadratic relationship as:

$$y = a + bx + cx^2$$

Where: y = yield on the sustainable farm divided by the yield on the conventional farm

x = standardised yield on the conventional farm

a, b and c = regression coefficients

Figure 6.7: Yield Variability Farm No. 1

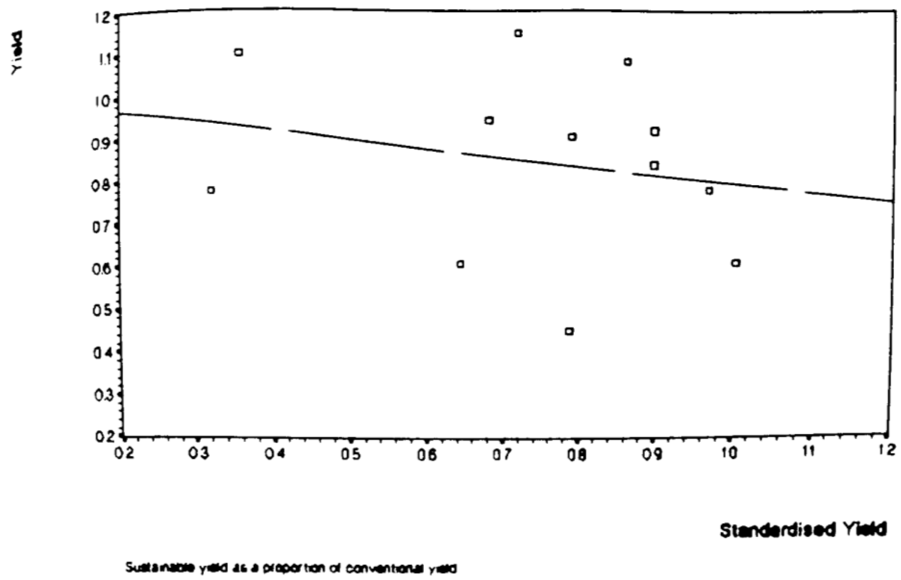


Figure 6.8: Yield Variability Farm No. 2

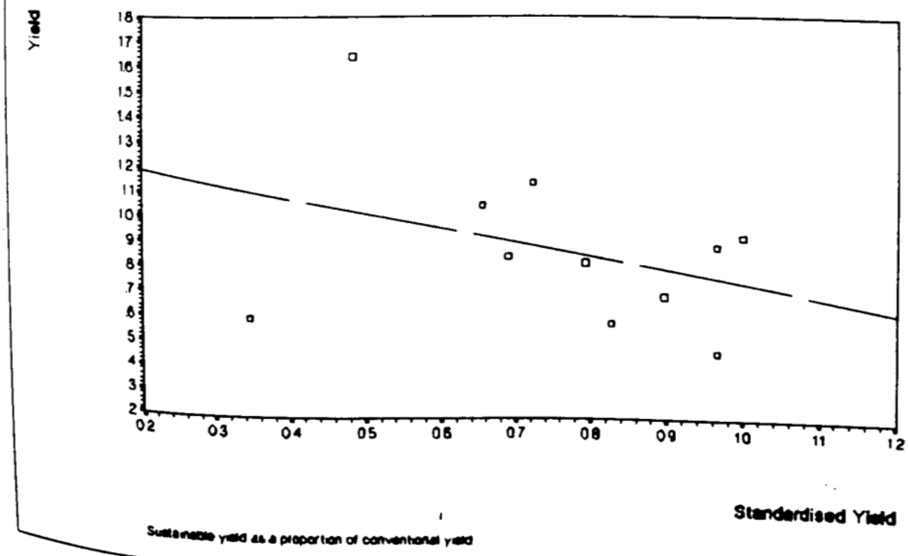
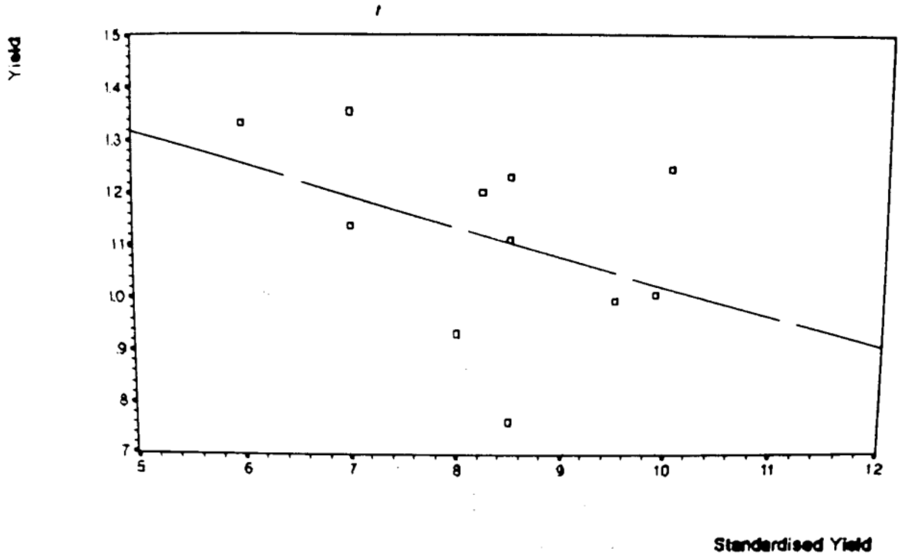
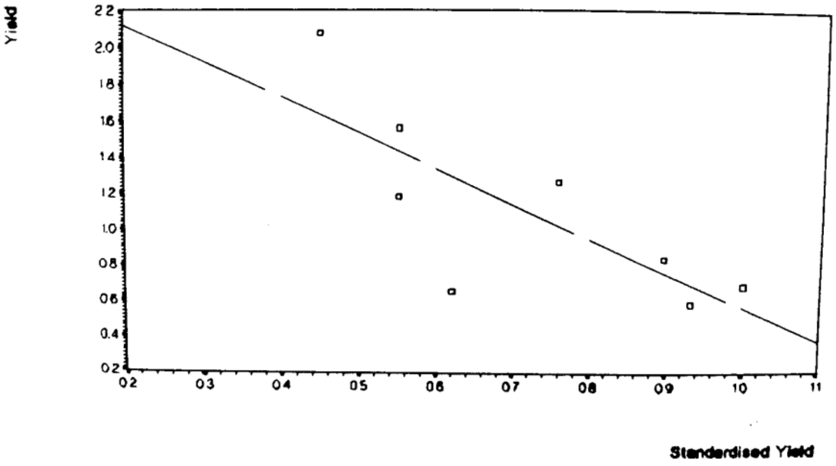


Figure 6.9: Yield Variability Farm No. 3



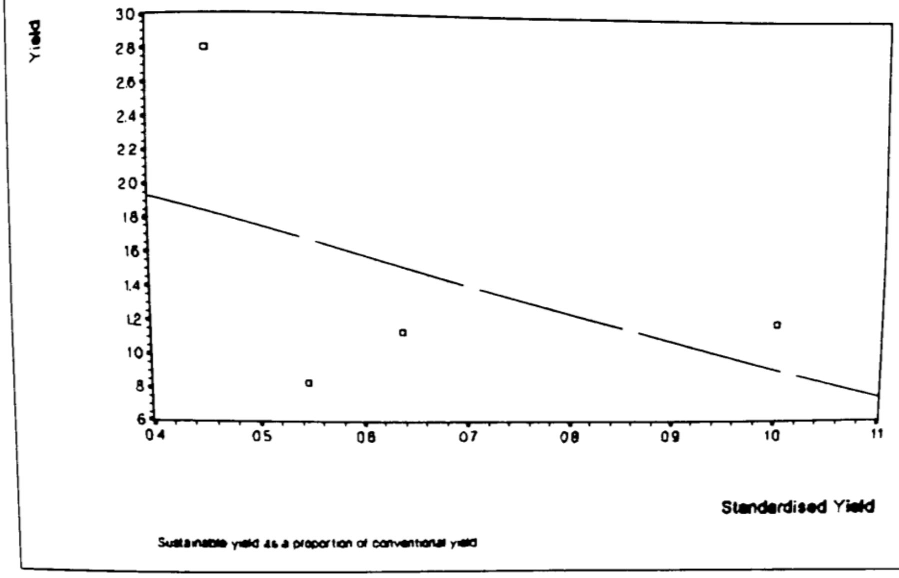
Sustainable yield as a proportion of conventional yield

Figure 6.10: Yield Variability Farm No. 4



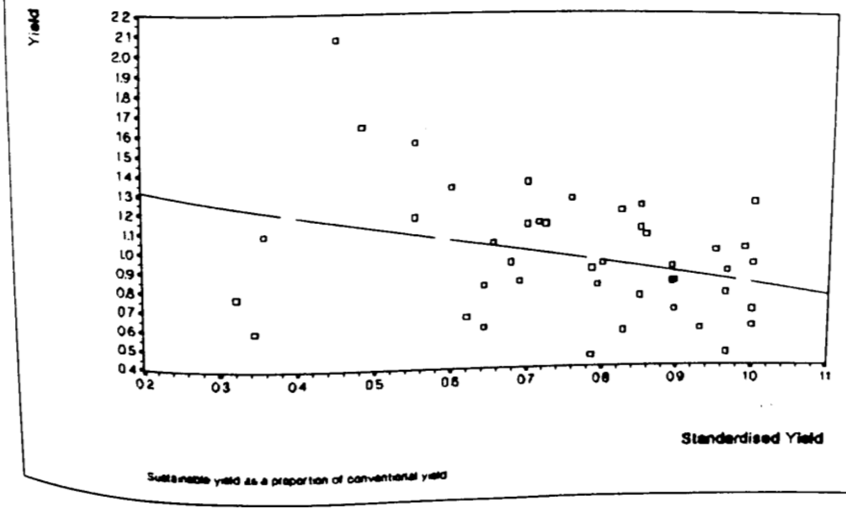
Sustainable yield as a proportion of conventional yield

Figure 6.11: Yield Variability Farm No. 5



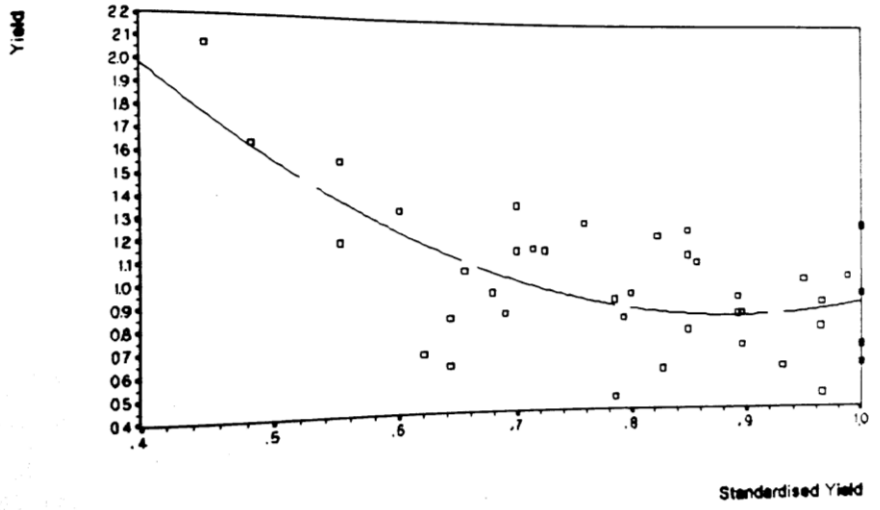
Sustainable yield as a proportion of conventional yield

Figure 6.12: Yield Variability - Four Farms



Sustainable yield as a proportion of conventional yield

Figure 6.13: Yield Variability - Four Farms



Sustainable yield as a proportion of conventional yield
(Quadratic fit with three outliers removed)

With the linear equation the relationship between the variables was detected ($y = 1.44 - 0.609 x$, with adjusted $R^2 = 0.102$). However, of the 43 observations, three are outliers (see Figure 6.12). Note that in all three cases the standardised yield is low compared with the other observations. Omitting these points is the same as omitting all points when the standardised yield is less than 40 per cent, which could be considered the cut-off point.

These exceptional observations influence the explanatory power of the variable considerably. Without these three observations the linear regression equation is: $y = 1.95 - 1.22 x$, with the adjusted $R^2 = 0.298$. If these three observations are omitted, the best fit is the quadratic function: $y = 4.65 - 8.59 x + 4.84 x^2$ (see Figure 6.13), with an adjusted R^2 of 0.410 per cent. This indicates that the yields on sustainable farms increase as a proportion of conventional yields as conventional yields decrease.

In summary, although the data are not such that firm conclusions can be drawn, indications are that the hypothesis of low variability of crop yields on sustainable farms as compared to those obtained under conventional management is supported.

6.3 Farmers' Perception of Yield Differences Under Sustainable and Conventional Management

6.3.1 Absolute yield

Farmers' opinions about the relative yield potential of sustainable and conventional agriculture were sought. The sustainable farmers were asked the question: 'If you had not changed to the sustainable agricultural system, how do you think that your yield would compare with your present yield?'. The conventional farmers were asked: 'If you were to practise sustainable agriculture, how do you think that your yield would compare with your present yield?'. It was realised that the answer to such a question can reflect at least two components: the conventional farmers' knowledge about sustainable agriculture and the confidence that it can be put into practice by them; and the perception of what happens on the sustainable neighbour's property. However, the advantage of such a question is that it eliminates the variation in yield due to management. It was made clear to the farmer that the question was meant to give an idea about the long-term yield potential, and should not reflect penalties for the learning process. Answers for both groups are recorded in Table 6.3.

Of the nine sustainable wheat growers from whom an answer was received, six felt that their yields were similar to those on conventional farms and three thought that they would be lower (the minimum indicated was 80 per cent of the conventional yields). The average of these nine answers was 95.6 per cent, which was not significantly different from 100 per cent ($p = 201$ with a Wilcoxon test). Two of the three sustainable barley growers expected similar or higher yields than on the conventional farm while one indicated that, since farming would not have been possible under the conventional system, yields at present on his farm were not comparable to those which could have been achieved under the conventional system.

Table 6.3: Farmers' perception of relative yields, and actual relative yields

Farmer	Perceived yield		Actual yield		
	Sust. farmer	Conv. farmer	Equal or higher on sust. farm	Total	Equal or higher as % of total
	% of conventional yields		Number of years		%
FS-CFS					
1.	100	25	5	8	63
2.	107	75	8	14	57
3.*	150	110	4	7	57
4.	n.a.	n.a.	2	3	67
5.	100	70	0	3	0
6.	100	150	4	5	80
7.	100	100	5	12	42
8.	80	80	6	14	43
Average:**	**105**	**83**	**34**	**66**	**50**
SS-CSS					
1.*	n.c.	50	1	7	14
2.*	100	100	13	13	100
3.	83	85	0	5	0
4.	100	86	1	5	20
5.	90	66	6	9	67
Average:**	**93**	**71**	**20**	**39**	**29**

n.a. = not available n.c. = not comparable
* = barley ** = non-weighted averages of wheat yields only

Of the nine conventional farmers who answered this question, seven felt that the yields would be lower under the sustainable system, with one farmer not expecting those yields to be higher than 25 per cent of the conventional yields. The other two thought that the yields would be equal or higher on sustainable farms. The average of these nine estimates was 82 per cent, which was significantly lower than 100 per cent ($p = 0.070$ in a Wilcoxontest). Two of the conventional barley growers expected equal or higher yields, and one expected the barley yield to be half under the sustainable system.

In Table 6.3 a measure of actual relative yields is added. The number of years in which the yield on the sustainable farm was similar (up to 0.2 tonnes per hectare less) or higher than on the conventional farm is depicted in the fourth column, the total number of years for which the comparison was available in the fifth, with the relative measure of these two values in the sixth. As mentioned before, some yields might be different from those on the counterpart farm because of factors of relative advantage for one of the two farms (such as non-random differences in rainfall, or differences in soil type). For individual farms an estimate of, for example, a lower yield under the sustainable system (as recorded in columns 2 and 3) can be consistent with an actual equal or higher yield (as recorded in column 6). In addition, conventional farmers may not consider actual yields on the sustainable farm an indication of what they themselves could achieve on their own farms. Calculating a correlation of the estimate and the actual values is therefore not valid. Nevertheless, the figures should be a guide to what the conventional farmer may have observed on the sustainable farm, which could influence the estimate.

In summary, the sustainable farmers in general perceived wheat yields under sustainable management to be similar to yields under conventional management. Conventional growers estimated wheat yields under sustainable management to be only 82 per cent of yields obtainable under conventional management. This was the case despite the fact that actual yields on the sustainable farms were equal to or higher than those on conventional farms in a considerable number of years.

6.3.2 Yield variability

As most (25) of the farmers answered that they considered the weather to be the major determinant of their income variation, they were asked whether the weather affected yields on sustainable and conventional farms in different ways. Most farmers (and in particular the conventional ones) did not understand the question. The theory of the effect of soil organic matter with its possible effect on drought resistance of crops was therefore explained. The question was answered mainly according to the type of farming practised.

Eight of the 13 sustainable farmers said that crops on sustainable farms coped better with stress. One farmer did not know. Most mentioned drought conditions, although one of the four who did not think there was a difference included flood conditions specifically. Another sustainable farmer mentioned that, in wet conditions, some mechanical field operations could not be carried out, which meant increased weed problems for sustainable farmers in wet years.

Nine conventional farmers felt that there was no difference between the way crops reacted to weather on the two types of farms. Two did not know. For one farmer the question was not relevant, as weather was not indicated as being the main source of variation in farm income. Ironically, the one conventional farmer who thought that crops did better on sustainable farms under drought conditions was the neighbour of one of the three sustainable farmers who did not think so.

In summary, the sustainable farmers in general thought that crops on their farms resisted drought conditions longer than those on conventional farms. Most conventional farmers did not share that opinion.

6.3.3 Yields in transition period

On the matter of yields during the transition period, only sustainable farmers were questioned. As most farmers did not have data suitable for analysis (see Section 6.2.2), it was considered that some information could be gained from recording farmers' opinion on this matter.

Of the ten producers who had changed from conventional to sustainable agriculture, four did not think the change made any difference to their yields in the initial years of transition. Three thought yields had decreased, and three that they had increased. The three who had observed decreases were all fully sustainable farmers, while two of the three farmers who reported increases in yields in the initial stages were semi-sustainable farmers. One of these reported a heavy past fertiliser use, and beneficial effects of decreasing the application rate, which lasted approximately five years. The other reported immediate beneficial effect of the use of different machinery, while yields dropped in subsequent years. The third (fully sustainable) farmer who reported increased yields in the initial stages mentioned that there had been a decrease before the transition. It took 14 years for the yields to stabilise.

Of the three who reported decreases, one said that his yields had not stabilised yet (he had figures from 1979 onwards, the time of conversion), while the other two mentioned an average of 12 years (10 and 14 years).

6.4 Summary and Conclusions

Yield patterns before, during and after transition from conventional to sustainable agriculture are interesting as they are one of the determinants of long-term viability of sustainable agriculture. Yet, this is an area which is difficult to assess. Apart from yields of all farmers in the last few years, historical data were difficult to obtain. Data suitable for time trend and variability analysis were available from only five of the surveyed pairs of farms.

The question whether there has been a difference between yields under the two farming systems cannot be answered in the affirmative. Although most conventional farmers thought that yields under a sustainable agriculture system must be lower than those obtained under conventional management, analysis of the data available from this survey does not bear this out. Between 1978 and 1987, average yields on sustainable farms were found to be significantly lower than on conventional farms in only one out of nine years.

The transition period is often mentioned as the time in which yields are low relative to what they would have been if continued with the conventional system. However, most of the sustainable farmers (seven out of ten) did not report a decrease in yields at that time. Two of the five farms for which several years of yield data are available reported a decrease. The figures show that a decrease in that period on those farms is plausible.

Is a drop in yields on sustainable farms likely after a number of years when the effect of conventional farming wears off? There were no signs in the data to suggest that this might be the case.

Yield differences between the two systems relating to climate, an aspect which is of considerable importance under Australian conditions, was observed by many sustainable farmers, but not by most of their conventional counterparts. The scant data available provide some support for the case that yields on sustainable farms are high relative to yields on conventional farms in years of dry weather conditions.

7 AUSTRALIAN WHEAT MARKETING ARRANGEMENTS AND SUSTAINABLE FARMERS[10]

7.1 Introduction

Marketing arrangements for agricultural products can influence opportunities available to sustainable farmers. Those relevant for Australian sustainable wheat farmers are the topic of this chapter.

In Australia, some products (such as wheat, eggs and milk) must be marketed via marketing boards. These boards mostly do not differentiate between produce from sustainable and conventional agriculture. However, this approach ignores some fundamental issues. One is the distortion of the market in favour of conventional agricultural production methods. This is the case because the appropriate market signals do not reach (potential) sustainable farmers if premiums, or part thereof, cannot be received by them. A second issue is consumers' right of access to organic produce.

7.2 Present Wheat Marketing Arrangements

Present wheat marketing arrangements in Australia are administered by the Australian Wheat Board (AWB), as specified in the Wheat Marketing Act 1984 and in complementary state legislation. Similar arrangements have applied since 1948. They involve granting to the AWB, through complementary Commonwealth/State legislation, compulsory acquisition powers over all wheat grown in Australia. The Act specifies that the AWB will

> '...perform its functions with the object of securing, developing and maintaining markets for wheat and maximizing the returns to growers from the marketing of wheat.'

The marketing activities of the AWB are supported by the State rail authorities and State bulk handling authorities. Until recently, the bulk handling authorities were the only authorised receivers which the AWB could appoint to receive the wheat compulsorily acquired by it.

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[10] An earlier version of this chapter is published in Wynen (1989b).

The AWB operates a pool marketing system for all wheat produced in a given season. Wheat is graded by the AWB's authorised receivers upon delivery from the farm into a number of broad marketing classes according to a number of characteristics of the wheat[11]. Growers who deliver a particular class of wheat, for example Australian Standard White, receive the average pool price obtained by the AWB from all sales of that class of wheat (from a season) across markets and through time. The price received by a grower does not necessarily reflect the final price obtained for the product; nor does it reflect differences in quality due to different production management systems[12].

Producers are paid a first advance by the AWB generally within three weeks of delivery based on the receival certificate issued by the Bulk Handling Authority (BHA).

Under the 1984 wheat marketing arrangements, the first payment is determined by reference to the Guaranteed Minimum Price (GMP) for wheat underwritten by the Australian Government. Separate GMP's are calculated for the major marketing categories of the AWB. The GMP is calculated as 95 per cent of the average of the gross pool returns for three seasons, estimated returns for the current season plus the two lowest of the three previous seasons' gross pool returns. Estimated AWB costs for the current season (mainly interest, marketing, market development, and administration) are deducted from the respective 95 per cent average of gross pool returns for the different categories to determine the GMP payable to growers. The GMP calculations involve two stages: the calculation of a preliminary GMP before harvest (in August), and a final GMP after harvest (in the following February). Ninety per cent of the preliminary GMP is paid to growers as the first advance on delivery of their wheat; the balance between that amount and the final GMP is paid as a second advance usually in the March after harvest.

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[11] The main determinants of the class are variety, geographical location, weight per volume, protein content and absence of foreign matter.

[12] A distinction is made here between the quality of wheat grown under a conventional and a sustainable management system (see Section 3.5.3).

To make the first payment to growers the AWB borrows commercially the required money from the domestic and international finance markets. After the borrowed monies have been repaid from sales receipts (or by the Commonwealth Government through the underwriting arrangements), further payments to growers are made when pool receipts exceed the first payment. These further pool payments are normally made over a two to three year period.

The costs of marketing wheat are also pooled to varying degrees. Individual producers bear the cost of moving their wheat from their farm to the export terminal; that is, land transport costs are not pooled. The costs of storage and handling are pooled on a State basis. The costs of marketing development and promotion, AWB administration and marketing costs, and the costs of borrowing money to pay growers their first advance are pooled on a national basis for the wheat of a season (these costs are generally deducted from the first advance payment to growers). Through the pooling of costs, individual growers do not necessarily bear the actual costs associated with marketing their own wheat.

The pooling of receipts and certain marketing costs can act against growers of speciality wheats such as organic wheat. The AWB marketing arrangements, especially the pool payment system, are not conducive to reflecting in the price paid to growers attributes of wheat for which some consumers are prepared to pay a premium. In addition, the AWB's marketing system has developed around the States' bulk handling and storage facilities. These are not designed to handle small parcels of speciality wheat where it is necessary to preserve the identity of the wheat. Thus, it is argued that the current marketing arrangements for wheat disadvantage growers of organic or other speciality wheats.

Sustainable farmers have two options with regard to marketing organic wheat. They can deliver their wheat to the AWB or they can market their own wheat under the AWB's 'grower to buyer' arrangements. At present, the AWB considers that it is not economically feasible to market wheat grown on sustainable farms as organic wheat; premiums therefore cannot be obtained for such wheat delivered to the AWB. Furthermore, even if premiums were received by the AWB, the pooling arrangement would inhibit distribution of these premiums other than via a (marginal) increase in the average pool price paid to all farmers.

The grower-to-buyer option is examined here. For this purpose the effects of the current system on the income of sustainable farmers when marketing organic wheat in the domestic market (Section 7.3) and in the export market (Section 7.4) are analysed. Proposed new wheat marketing arrangements are examined where relevant to organic wheat marketing (Section 7.5). The issues are summarised in Section 7.6.

7.3 Sustainable Farmers and the Domestic Wheat Market

As noted, sustainable growers are currently faced with two options for marketing their wheat domestically: either they deliver it to the AWB or they market it under the AWB's grower-to-buyer arrangements.

Under the first option, sustainable farmers effectively forfeit the opportunity to obtain a higher price for their organic wheat - it is just pooled along with wheat produced by conventional methods and sustainable growers receive the average pool price for the grade they deliver.

The returns received by farmers from Australian Standard White (ASW) wheat sold to the AWB are shown in Table 7.1 (column 2). The 'Gross Pool Price' is the gross amount paid out to farmers for a particular year up to October 1988.

Certain costs (mainly incurred by the AWB) are deducted from the market returns before the gross pool price is calculated. The main one is interest (Table 7.1, column 3) on borrowings to finance the first payment to farmers, which has varied between $10 and $20 per tonne since 1984-85 (AWB 1988). Other costs (encompassing AWB marketing, Treasury, administration, depreciation and promotion (Table 7.1, column 4)), have been between $1 and $4 per tonne since 1984-85 (AWB 1988).

In making payments to growers the AWB deducts a number of costs and levies from the gross pool price. The main costs for Australian Standard White (ASW) wheat are shown in Table 7.2. Some of these vary over the years, and they differ somewhat between the States. In 1986-87 the costs were highest in New South Wales ($44.26 per tonne) and lowest in South Australia ($27.26 per tonne). The (weighted) Australian average was $36.22 per tonne.

Table 7.1: Wheat prices for producers in the Australian domestic market: 1979-80 to 1987-88 ($/t)

Year	Gross Pool Price	Interest	Other AWB Costs#	Human Consumption Price	Domestic Selling Costs@	Margin (5-2-3 -4-6)
1	2	3	4	5	6	7
1979-80	155	6.6	0.6	131	3.0	-34.1
1980-81	147	9.8	1.2	156	2.8	-4.8
1981-82	150	12.1	1.0	187	3.2	20.6
1982-83	178	6.8	2.0	203	3.4	12.8
1983-84	162	11.9	1.0	219	4.6	39.5
1984-85	164*	19.9*	1.6*	211	7.4	8.1
1985-86	159*	12.9*	2.5*	214	17.1	22.5
1986-87	140	10.9*	2.4*	189	17.3	18.4
1987-88	144*	7.5*	3.4*	193	17.9	20.2

Source: AWB Annual Report (1988) and personal communication AWB (October 1988)

Note:

Prices are for ASW wheat as at October 1988

\# = AWB marketing, Treasury, administration, depreciation and promotion

@ = From 1979-80 to 1983-84 'Domestic Selling Costs' are reflected in the 'Margin' (column 7), with the exception of the Tasmanian freight levy, which is recorded in column 6. From 1984 'Domestic Selling Costs' are $16 + Tasmanian freight

* = Payments not completed

n.a. = not applicable

Table 7.2: Marketing costs deducted from gross pool price in New South Wales: 1986-87 ($/t)

Freight (average for all NSW growers)	24.49
Bulk Handling Authority Charge	16.70
Ceres House	0.10
Wheat Research	0.40
Wharfage	1.75
Two port loading	0.00
Carryover costs	0.82
TOTAL	44.26

Source: AWB Annual Report (1987)

The grower-to-buyer arrangements provide sustainable growers with an opportunity to obtain a higher price for their wheat and to avoid some of the costs detailed in Table 7.2. These arrangements allow growers, subject to the approval of the AWB, to negotiate directly with buyers the price to be received for their wheat and to arrange for the wheat to be transported directly from the grower to the buyer rather than to be delivered to the AWB's authorised receiver. However, the transaction goes officially via the AWB, although it is on paper only. Some costs charged by the AWB to farmers who sell via the AWB (as shown in Table 7.2) are reduced when direct delivery takes place, as in a grower-to-buyer arrangement. Freight is not deducted from the returns received from the AWB, and the BHA charge is decreased from $16.70 to $5 per tonne in New South Wales (the levies vary somewhat in the different States). Of the other costs only the Ceres House levy ($0.10 per tonne) and the Wheat Research levy ($0.40 per tonne) are deducted. For example, of the $19.77 non-freight marketing costs deducted from the gross pool price in New South Wales for the year 1986-87, sustainable farmers buying their own wheat back from the AWB would pay $5.50.

Technically, in a grower-to-buyer arrangement, growers buy their own wheat back from the AWB and then sell it, either to themselves or directly to a third party. The price for which the wheat is bought from the AWB is called the 'Human Consumption Price' (see Table 7.1, column 5), the same price all buyers (mainly millers) pay. Before 1984 it was set with the aid of a formula in which the AWB costs of selling were covered, with the exception of the Tasmanian freight levy which was still to be deducted. Since 1984 it is set quarterly by averaging export prices being asked for the forward quarter and corresponding prices for the past quarter. This amount is increased by a margin intended to cover additional costs incurred by the AWB in servicing the domestic market, plus the Tasmanian freight levy. From October 1984 these additional costs are set at $16, plus the Tasmanian freight levy. They include: BHA carry-over (storage) costs, interest on carry-over, price stabilisation, crop quality information, deferred payments terms, quality selection, and AWB administration costs. The $16 also cover costs associated with other benefits provided by the AWB to buyers of wheat, including:

- The right to select the best quality wheat (within a grade), reserved in a silo of the buyer's choice.
- An option on a particular supply, which provides security of supply. At the same time, if too much wheat has been reserved, the buyer has the option not to buy it (to 'pass it in').
- Credit facilities for an average of approximately 45 days when delivery is taken.

The value of these benefits is difficult to quantify.

Compare now two different groups buying wheat from the AWB: millers and sustainable farmers. Millers buy the wheat for the human consumption price and receive certain services for the costs built into this price. For sustainable farmers the transactions of selling and buying are on paper only - the organic wheat never physically enters the AWB marketing system. Certain costs incurred by the AWB in the process of selling wheat on the domestic market, and which are a component of the human consumption price, do not apply to the wheat bought by sustainable producers. Yet they have to bear those costs. For example, sustainable farmers do not use the provision to reserve wheat, which means no use is made of storage facilities and payment deferrals (credit). In addition, sustainable farmers do not have the opportunity to pass in wheat once it is bought from the AWB. This adds an element of risk to the sustainable farmer's marketing activities, to which millers are not subjected.

As organic wheat does not enter the AWB marketing system sustainable farmers need to provide services to themselves (for example storage) and to their buyers (for example credit), otherwise provided by the AWB for the $16. It is not clear how high those costs are which are now incurred by the sustainable farmers. However, it is likely that some costs are incurred, such as for storage (although care must be taken not to double-count storage and interest already deducted from the price of wheat sales to the AWB), deferred payment terms for the third party, and the risk of not being able to sell the wheat in the organic market nor back to the AWB. It seems reasonable to assume that these costs vary between $0 and $16 per tonne.

Another way in which sustainable farmers could be disadvantaged is by the inflation of the human consumption price due to the method by which it is calculated. As mentioned before, the human consumption price is set quarterly by averaging the export price being asked for the forward and that for the past quarter. The extent to which the asking price has been above realised prices has varied considerably according to volume sold and level of competition on the world market. In recent years for small volume sales, realised price has been below offer price by generally less than $5 per tonne. However, for large volume sales it has been up to $20 per tonne below the offer price . Although the calculation of the effect of this discrepancy on the human consumption price is complicated, the difference can be approximated by deducting the gross pool price, interest and other AWB selling costs, both on the domestic and export market, from the human consumption price. It is called the 'Margin' in Table 7.1, column 7, and can be seen as a guide for the magnitude of the difference. The margin amounted to $8 or more per tonne since 1981-82.

Sustainable producers who buy their wheat from the AWB pay the same as millers who also pay the human consumption price. This means that, when the wheat is sold to consumers, an increase in wheat price due to the calculation method (as is the case where the difference is due to a difference between asked and realised price) is not likely to advantage one seller of wheat over another. However, it is possible that consumers are more inclined to buy the lowest priced product (even when aware of differences in quality) when prices are relatively high. At present, little is known about the effect of increased prices on the demand for organic wheat. It seems likely, however, that organic wheat is considered more of a 'luxury' than conventional wheat by many buyers. If that is the case, an increase in price decreases the demand for organic wheat relatively more than that of conventional wheat. Without empirical data this effect is difficult to measure; no effort has been made to quantify it here.

In addition to the costs associated with buying wheat from the AWB for which no services are received or which decreases the competitiveness of organic wheat, payments are associated with selling wheat to the AWB in the first place (see above). Payments to growers under the grower-to-buyer arrangements are through the AWB pooling system. This means that growers have to pay the research and Ceres House levies and the various costs which are pooled on a national basis: interest, AWB marketing and administration costs. Although some of the research carried out currently into the wheat industry undoubtedly benefits all farmers, in general sustainable growers do not feel that their research requirements are catered for (see Section 5.5.3.3). The payment of the Ceres House levy and the national pooled costs also places sustainable growers at a financial disadvantage; either they receive no benefits from the services of the AWB or they may have to bear the same cost, such as interest, twice. In this case, sustainable growers share in meeting the pool cost of interest on monies borrowed to pay the first advance payments ($10 to $20 since 1984-85) and have also to bear the cost of interest associated with the money used to buy back their organic wheat. Other costs pooled on a national basis including the Ceres House levy and research have been between $2 and $4 in recent years. Furthermore, sustainable farmers have to pay a charge to the appropriate State Bulk Handling Authority even though their wheat is not delivered to the Authority. As mentioned, the amount varies between the States and amounts to $5 per tonne for growers in New South Wales. This places sustainable growers at a financial disadvantage because they still have to provide their own storage and handling facilities.

In summary, the present legislative arrangements impose a number of costs on sustainable growers in marketing their organic wheat domestically. This is because, to stay within the law, wheat has to be sold to, and bought from, the AWB before it can be sold as organic wheat by producers. In the process several costs are incurred without gaining the benefit of the service for which payment is made. In 1986-87 these costs amounted to between $19 and $35 per tonne (see Table 7.3 and Figure 1) in New South Wales, consisting of interest and other AWB nationally pooled costs, including Ceres House and research levies ($13.80 per tonne), BHA charges ($5 per tonne), and the cost of selling wheat to domestic buyers ($0 to $16). In addition, the high price of wheat on the domestic market, due partly to differences between the offered and realised wheat price on the export market, might well decrease the competitiveness of organic wheat.

Table 7.3: Costs incurred by sustainable farmers in New South Wales when marketing organic ASW wheat domestically: 1986-87 ($ per tonne)

	Minimum	Maximum
Interest and other AWB costs and levies	13.80	13.80
BHA	5.00	5.00
Costs incurred to sell to domestic buyers	0.00	16.00
TOTAL	**18.80**	**34.80**

In addition, decreased demand due to a relatively high human consumption price is likely.

7.4 Sustainable Farmers and the Wheat Export Market

Sustainable farmers who want to export wheat need to engage in selling and buying transactions with the AWB in a similar fashion to that described for the domestic market. Thus, in exporting their organic wheat, sustainable growers still have to bear the same financial disadvantage of $19 due to interest, Ceres House and research levies, and other nationally pooled costs, and the BHA charge. And, as in the domestic situation, other additional costs may be borne.

Organic wheat destined for export is bought from the AWB for a price equal to quotations for Australian wheat for export on that particular day. The quotations are set '...according to the commercial judgement of the Board, taking into consideration the world supply-demand situation as reflected in the prices offered by competing exporters, particularly the United States. Essentially, the Board bases its quoted price on that of competing US wheat...Since 1985 the presence in the market of increasingly significant quantities of subsidised wheat has had the result that often the published quote is not indicative of prices realised in many of Australia's markets.' (BAE 1987b).

Once the organic wheat is purchased from the AWB at the daily export asking (or quoted) price, the sustainable grower seeks to obtain permission to export via a 'Recognised Exporter'.

The source of the costs of sustainable growers additional to the $19 mentioned above is the difference in quoted and realised price (as discussed in Section 7.3). By paying a higher price for their wheat than the world price, the competitiveness of sustainable growers on the world market is reduced; so too are the potential profits (or price premium) to be obtained from the export of their wheat. In essence, these potential profits are obtained by the AWB and so shared by all farmers through the pooling system. As the realised price for speciality wheat is closer to the daily quoted prices than that of large parcels of wheat, the level of the profit reduction is likely to be on the lower end of the estimate of between $0 and $20 per tonne mentioned in Section 3.3.

In summary, the cost of marketing organic wheat on the export market under present legislative arrangements is similar to that sold on the domestic market. The total of $19 to $39 (see Table 7.4) in 1986-87 for growers in New South Wales is made up of $13.80 for AWB marketing charges, $5 for BHA-charges, and between $0 and $20 for the difference in AWB quoted and realised prices for wheat on the export market.

Table 7.4: Costs incurred by sustainable farmers in New South Wales when marketing organic ASW wheat on the export market: 1986-87 ($ per tonne)

	Minimum	Maximum
Interest and other AWB costs and levies	13.80	13.80
BHA	5.00	5.00
Difference between quoted and realised price	0.00	20.00
TOTAL	**18.80**	**38.80**

7.5 Proposed Wheat Marketing Arrangements

In July 1988 the Commonwealth Minister of Primary Industries and Energy announced proposed changes in the existing wheat marketing arrangements. Although new legislation will be introduced in the Autumn 1989 session of the Parliament, some of the details were outlined in the media release of 28 July 1988.

It is proposed that the domestic market be deregulated. In the transition period the permit system (which was applicable in the past to feed wheat only, and which allowed farmers, for a small fee, to sell wheat directly to livestock producers) is to be extended. The grower-to-buyer arrangements is to be made 'more competitive'. After the transition period, the compulsory acquisition powers of the AWB are to be terminated. If the domestic market is indeed freed up, the main disadvantages of marketing organic wheat will disappear. However, it should be noted that the continued GMP arrangements for growers selling through the AWB are a potential source of discrimination against sustainable growers, if no GMP arrangements are available for those who cannot sell through the AWB. Also, as the storage and handling of wheat is controlled by state legislation, the freeing up of the market at Commonwealth level does not necessarily imply that the BHA charges will disappear. Changes in the attitudes of the State grower organisations and State governments will be necessary for that to occur.

Although, in the export market, arrangements would give the AWB more flexibility, the proposed changes are not relevant in connection with increased flexibility in organic wheat marketing. The AWB will maintain control of the export of milling wheat (for human consumption), which is the category of most interest to sustainable farmers who export. The cost disadvantages identified in Section 7.4 are likely to continue to apply, with the possible exception of the BHA charge.

7.6 Summary and Conclusions

The most notable features of the Wheat Marketing Act 1984 in connection with the marketing of organic wheat are the compulsory acquisition powers of the AWB and the pooling arrangements of costs and returns. By being required to deliver their wheat to the AWB and being part of the pooling arrangements sustainable farmers have had to pay for certain costs for which no services are received. The total costs to sustainable farmers for being part of the pool in New South Wales in 1986-87 were between $19 and $35 per tonne when the wheat was sold on the domestic market, and between $19 and $39 per tonne when it was sold on the export market. In 1985-86 similar costs occurred. For 1987-88 and 1988-89 final estimates are not available.

With the proposed changes in wheat marketing arrangements, disadvantages for sustainable farmers on the domestic market might disappear. However, if sustainable farmers wish to export organic wheat, the disadvantages will remain.

8 EFFECTS OF FARM POLICIES AND MARKET PRICES ON INPUT USE AND OUTPUTS[13]

8.1 Introduction

Agricultural management systems do not exist in a vacuum. Farm policies regarding input pricing and marketing arrangements, for example, have a direct impact on the profitability and the degree of attractiveness of a particular system, as do movements in prices independent of policies. These factors influence the choice of rotation systems, and the use of inputs such as fertiliser and pesticides, directly impacting on the degree of externalities.

Policies of most interest here are those which affect sustainable and conventional farming in different ways. Which are these? What is the difference in effect on private net returns and externalities?

Inputs used in different ways in the two systems include synthetic fertilisers and pesticides. Policies examined in this chapter encompass subsidies and taxes on the use of these inputs. Subsidies have been paid on fertilisers in the past. In addition, society subsidises fertilisers and especially pesticides indirectly by being subject to negative externalities. The introduction of a tax on the use of these inputs is one way to reach a more efficient allocation of resources.

As shown in Chapter 7, the wheat marketing system in Australia leads to marketing costs for sustainable farmers which are higher than those for conventional farmers. This effectively results in lower premiums than could be achieved without these costs and in decreased demand for the product. Rationalisation of marketing arrangements would lead to higher prices for sustainable farmers. The effect of higher prices on input use and on returns to farming is explored.

A linear programming model is used to illustrate the order of magnitude of the effect of changes in policy and in market prices. Little effort is

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[13] An earlier version of this chapter is published by Wynen and Kennedy (1989).

made to use sophisticated production functions, and the constraints are kept simple. The results can therefore not be used for detailed policy analysis. They rather indicate trends in the effects on input use (with its external effects) and returns to farming.

8.2 Method

Farm management involves choosing among a considerable number of possible activities. The choice determines the returns (in both financial and non-financial terms) to farming. Dent, Harrison and Woodford (1986) summarise several ways in which the problem can be approached. These include whole farm budgeting, partial budgeting, and gross margin analysis. However, these '...permit neither a rigorous search of all combinations of activity levels, nor a systematic approach towards determination of the optimal combination.'.

Linear programming is suitable for the determination of a best course of action given a particular linear objective and linear constraints.

In this chapter a prototype model, or case study, is developed to predict the impact of changes in outside factors such as agricultural policies at the farm level. No account is taken of a downward sloping demand for agricultural output in estimating the effect of increased supply on output prices and farm revenue. This seems reasonable for the near future. The solution indicates what action individual farmers are likely to take in response to the implementation of policies regarding fertiliser, pesticide and output prices.

The model was constructed for a representative cereal/livestock farm in the Eastern Riverina region. There are two versions of the model. In the first, conventional farming practices are followed. The basic data for the conventional farm are taken from Reilly and Godyn (undated). A second version relates to sustainable farming. As no comparable data were available from the work of Reilly and Godyn, figures for the sustainable farm were imputed. The figures differ from the conventional farm according to the relative differences between the two farming systems found in the comparative survey of sustainable and conventional farms reported upon in

Chapter 5. It is assumed that relative input use between the two farming systems remained similar between the survey period (1985-86) and 1987 (for which Reilly's and Godyn's figures are valid). It is likely that the effect of inflation and a change in relative input prices between the two years did not affect relative input use other than in a minor way.

The rotations were constructed according to the situation on two Riverina farms in the survey (see Section 8.3.3.8). In general, the choice of rotation and inputs used in rotations is made with regard to prices of inputs and outputs. Where prices in the survey differed considerably from the data in Reilly and Godyn (undated), survey data were also used for the conventional farmer in stead of taken from Reilly and Godyn (undated). This is indicated in the text where appropriate.

8.3 Formulation of Problem

8.3.1 Introduction

Details about the objective function and the constraints are discussed below.

Risk and uncertainty are not included in the model. These were omitted for simplicity. Differences in risk between sustainable and conventional farming are likely to be due to two factors. One, sustainable farmers consider that lack of knowledge is the largest problem regarding this type of farming (see Section 5.5.3.3.), which must increase the degree of uncertainty under which they operate. Two, as sustainable cereal/livestock farmers use significantly less inputs than conventional farmers in South-eastern Australia (see Section 5.4.3.), the risk of obtaining negative returns to farming in climatically adverse years must be lower for sustainable than for conventional farmers.

Intertemporal aspects, such as investment or discounting, are not included in the model - again for simplicity. While this is not a dynamic model, time is included implicitly by specifying entire rotations (see, for example, Dent, Harrison and Woodford (1986)). Different rotations are included to reflect management requirements concerning, for example, farmers' objectives, soil fertility and pest problems. The rotations included are presented in Table 8.2. Of course, the stage in the rotation varies from paddock to paddock. Inputs are used and outputs accrue over the whole of the rotation period and not, for example, all at the beginning or the end of the period. They are included here as the total of that period divided by the number of years in the rotation; that is, on an annual basis.

8.3.2 Objective function

The objective is to maximise financial returns to farming. These are calculated as total revenue minus costs. The costs for the cropping enterprise are: fertilisers, pesticides, machinery costs, labour and most of the marketing costs. Cost of transport from the farm to the silo, a minor cost compared to that which is deducted for rail transport (see Section 7.3), is not subtracted. For the stocking enterprise the costs are: veterinary chemicals, shearing, crutching and marketing costs. Cost of administration and insurance is not deducted from either enterprise.

Since neither stocking rate nor gross returns per hectare grazed were different between the two management systems (see Section 5.4.2.2.) it is assumed that livestock prices were similar. Prices used in the model are therefore the same for the two versions of the model.

Wheat prices obtained by sustainable farmers were found to be 32 per cent higher than those on conventional farms ($p = 0.018$) (Section 5.4.2.1.). Although it might have been of interest to see the difference between the two farms with equal wheat prices, the choice of rotation and fertiliser rate is likely to be influenced by actual prices received. Reilly and Godyn (undated) estimated the returns to wheat to be $75 per tonne. However, the surveyed conventional farmer in that area received $100, which is the amount used in the model. The price imputed for the sustainable farmer is $130 ($100 plus 32 per cent, rounded off). The sustainable farmer in the survey received $150 per tonne of wheat. Reference to that amount is made where appropriate.

The objective function is maximised subject to the constraints discussed below.

8.3.3 Constraints

8.3.3.1 Land

The land resource is usefully appraised in terms of quantity and quality.

Total area operated consists of arable and non-arable land. The figures used in this model are as follows:

. total area operated:	1000 ha
. arable area:	700 ha
. non-arable area:	300 ha

For this analysis it is assumed that soil quality is the same for both farms. One of the criteria for the selection of the conventional farms in the survey described in Chapter 5 was similarity in soil type to that on the sustainable farms. However, a factor which influences the quality of the soil is the farm management system. With the change in management system a change in soil quality is likely. No physical data were collected on this variable. However, the difference is assumed to be reflected in output per unit of input.

8.3.3.2 Fertiliser

The sources of nutrients used are rock phosphate (15.5 per cent P) and Starter 12 (11.7 per cent N, 22.7 per cent P, and 2.3 per cent S) on the sustainable and conventional farm, respectively. The difference between the two types of fertiliser, apart from the difference in nutrient levels, is that the phosphorus in rock phosphate is not water-soluble, while that in Starter 12 is. This means that Starter 12 causes more off-farm pollution, for example in waterways.

For the cropped area five levels of nutrients are included for each of the four rotations in the model. Details, together with the effect on wheat yield, are described in Section 8.3.3.7 and are shown in Appendix 7.

On the non-cropped arable area fertilisers are only used in the two rotations with an emphasis on stocking (rotations 2 and 4; see below).

The sustainable farmer also applies lime 18 months before planting of the first crop in the rotation. This is used partly to combat certain weeds.

8.3.3.3 Pesticides

Pesticides in the cropping phase are used only on the conventional farm, in the form of herbicides on wheat and peas, and insecticides on peas.

The yield response to herbicides depends on many factors: physical conditions such as temperature and humidity; biological factors such as maximum weed-free yield and pre-treatment pest density; and rotation and cultivation practices. Pannell (1989a) constructed a yield response function in which several of these factors can be accommodated. However, their inclusion in the model is beyond the scope of this thesis, and a somewhat simpler approach is taken here. Assumptions relating to the pesticide response function are as follows.

The first assumption is that the 2.3 tonnes of wheat per hectare obtained by the conventional farmer when the base rate of fertiliser is applied (see Section 8.3.3.7) is close to the weed-free maximum obtainable yield. This seems reasonable, as the farmer had used the recommended rate, and Pannell (1989a) reports that 'Label rates are generally specified at levels sufficient to kill most of the target organisms most of the time.'

The second assumption is that the weed density is 300 per m^2. There is no way to identify whether this is a realistic assumption. It is the highest figure for which Pannell (1989a) shows estimates. The reason for choosing it here is that it is the density for which Pannell (1989a) shows the yield loss as compared to the weed-free yield. For a yield of 2 tonnes per hectare it is 0.71, and for 3.0 tonnes per hectare it is 0.75 tonnes of wheat lost per hectare. For the purposes of this study 0.73 seemed a reasonable figure to take. Yield without the use of herbicide is therefore 2.3 minus 0.73 equals 1.57 tonnes per hectare.

The active ingredient of the herbicide used (Hoegrass) is 0.28 kg per hectare. Assuming then that this gives a yield close to the maximum, *ceteris paribus*, with 1.57 tonnes per hectare obtainable without herbicides, the following response function is found:

$$y = 1.57 + 5.21\ x - 9.31\ x^2$$

Where y = yield, and x indicates the level of active ingredient (kgs/ha).

This method is employed to estimate the effect of post-emergence herbicides only on wheat, the main crop. The three levels of pesticides are applied on each of the five levels of fertiliser applications within each of the four rotations. Other pesticide applications, such as 'spray-topping' (a herbicide application approximately half a year before planting the first crop of wheat in order to prevent weeds reaching the seeding stage), and herbicide and pesticide applications on peas, are included at the rate shown in Reilly and Godyn (undated). No pesticides are used on oats. The results are shown in Section 8.4.2 and Table 8.5.

8.3.3.4 Livestock

Most of the livestock figures are taken from Reilly and Godyn (undated) for a medium-wool, self-replacing merino flock.

Results from the survey are the basis of the decision to cut the stocking rate suggested in Reilly and Godyn (undated) by half (from eight to four dry sheep equivalent (DSE)). The reason is that on the two farms in the Eastern Riverina in the survey, the stocking rate on the arable non-cropped area is 3.6 and 4.5 DSE on the sustainable and conventional farm, respectively. Since no statistical difference between the two system was found in stocking rate on farms with livestock (see Section 5.4.2.2.), equal stocking rates were employed for the two farms in the model. As the farms in the survey are in the driest part of the area for which Reilly's and Godyn's (undated) data apply, the difference is plausible. Since potential stocking rate is a variable which influences the rotation systems followed, and the rotations in the model are constructed on the basis of data from the survey farms (see Section 8.3.3.8), the average stocking rate of the Riverina survey farms was adopted.

Stocking rates in the different rotations are adjusted for area in oats where oats are grown for dual purpose (grain and grazing). The adjustment was made according to the survey farmers' opinions about the extra carrying capacity obtained by the cultivation of oats.

As no significant differences were indicated in wool yield per sheep in the comparison between sustainable and conventional farms in the survey (see Section 5.4.2.2.), the same figures for these variables are used for the two farming systems in this model.

The cost for veterinary chemicals is calculated for the sustainable farmer as 26 per cent of that for the conventional farm (see Section 5.4.1.3.).

8.3.3.5 Labour

Labour supply is not constrained. It is assumed that the owner/operator supplies labour and that any further labour is hired. The rate is set at $10 per hour, and is deducted in full from the returns.

Labour requirements for the different operations on both types of farms are taken from Reilly and Godyn (undated). In that publication requirements are specified for the different operations with a specified package of machinery. As the conventional farm was allocated higher machinery and equipment costs than the sustainable farm (see Section 8.3.3.6), it was assumed that less labour was needed on the conventional farm. Differences in labour cost were calculated according to relative capacity of the machinery and equipment items in the two models.

Times for operations related to planting were calculated as the total of the different activities carried out, irrespective of yield. This involved, for example, an extra cultivation for the sustainable farmer before the first crop. Half of the harvesting time set by Reilly and Godyn (undated) is assumed to be fixed. The other part is made dependent on the yield. With the basic yield it is equal to the fixed cost.

8.3.3.6 Machinery and equipment

Reilly and Godyn (undated) calculated the variable and fixed costs of packages of machinery, which included a tractor, disc plough, scarifier, wideline cultivator, combine, spray unit and a harvester.

Two different packages are used for the two farms. For the sustainable farm a package totalling \$196,618 is used, while the conventional farm is attributed machinery to a value of \$317,910. The reason for the different treatments of the two farms in the model is the considerable difference in depreciation of machinery and equipment per hectare operated in the survey of sustainable and conventional farmers (Section 5.4.1.6.). Some impression of the applicability of the two packages for the two farms in the model can be gained from comparing the size of the tractors in the survey to the size in Reilly and Godyn (undated). The package of machinery used to calculate costs on the sustainable farm includes a tractor which is 17.3 per cent larger than the average used on the sustainable farms in the survey, while the equivalent for the conventional farm is 17.7 per cent larger than the average of the conventional farms in the survey. So, although figures for exactly similar machinery and equipment are not available from Reilly and Godyn (undated), relative values between the sustainable and conventional farm in the model and the survey are similar.

8.3.3.7 Yield

Yield figures for the different crops on a conventional farm for a particular fertiliser rate are based on a quadratic fertiliser response function, as shown in Table 8.1. The function is calculated by assuming three points.

The base point is taken from Reilly and Godyn (undated) for a particular fertiliser rate. This figure is similar to the yield obtained by the conventional farmer in that area in the survey, who used a similar fertiliser rate.

Table 8.1: Fertiliser response functions

Crop	Sustainable	Conventional
Wheat	$0.7 + 10.75\,x - 18.75\,x^2$	$0.7 + 43\,x - 300\,x^2$
Oats	$0.8 + 6.25\,x - 11.25\,x^2$	$0.8 + 25\,x - 180\,x^2$
Peas		$0.7 + 8\,x - 19.2\,x^2$

x = fertiliser levels (t/ha)

The second point refers to the situation where no fertiliser is applied. A yield of 0.7 tonnes per hectare of wheat (0.8 tonnes per hectare of oats) is assumed. This figure is used by Clark, Johnston and Matuska (1984) in their application of a linear programming model for a representative farm in southern New South Wales, and seems a reasonable estimate. For peas the estimate is set equal to that of wheat, 0.7 tonnes per hectare.

The third point is the maximum (diminishing returns to fertiliser were assumed). An increase of fertiliser rate on the conventional farm of, for example, 20 per cent or 10 kgs costs an extra $4 per hectare. At a wheat price of $100 per tonne and assuming that farmers try to equate marginal costs with marginal benefits, an extra yield of 0.045 tonnes per hectare is needed to cover extra fertiliser costs alone. It seems therefore reasonable to assume that the maximum, the third point, is within 10 per cent of the yield at the observed fertiliser rate (the base point).

Once the response function is established, yields for other than the actual (base) rate can be calculated. The rates discussed in this chapter are 20 and 40 per cent higher and lower than the actual rate. For the conventional farmer, rates explored are therefore, apart from the 50 kgs actually used, 30, 40, 60 and 70 kgs (see Appendix 7).

For the sustainable farmer the yield at the base level of nutrient application is based on relative figures in the survey (see Section 5.4.2.1.), which were similar for the two farmers of that area. For the other fertiliser levels, similar response functions to those employed for the conventional farmer are used. The reason it was necessary to construct a separate response function is that the sustainable farmer used a different kind of fertiliser, resulting in a different quantity used in absolute terms.

Yields are not only a function of nutrients supplied, but also of the crop's place in the rotation. For example, wheat yield figures by Reilly and Godyn (undated) relate to the second crop in the rotation (2.1 tonnes per hectare, shown in Table A.7.1. under 'level of application' 3, for the sustainable farmer, although the conventional farmer did not grow a wheat crop in the second year in that rotation (see below)). Ceteris paribus, for a first crop yield would be higher (for example, 2.3 tonnes per hectare). As rotations are an important variable in this chapter, basic yields are estimated for the different fertiliser rates under different rotation systems with reference to the basic yield in the first rotation. They are speculative, and are shown in Appendix 7, Tables A.7.1 to A.7.4. Yield response functions for all rotation systems were calculated in the manner described earlier, and yield figures for fertilser rates other than the base rate were imputed in that way.

The response function for oats and peas are derived in a similar way as the one described for wheat. The sustainable farmer has no peas in the rotations.

8.3.3.8 Rotation requirements

There are four different rotations, the details of which are shown in Tables 8.2 and 8.3. In Table 8.2 the crops are shown in individual years. In Table 8.3 the percentage of arable area under each crop is shown for any year in the rotation.

The basic rotation (rotation 1) is similar to the actual rotation on the sustainable farm and the conventional neighbour farm in the Eastern Riverina area in 1985-86. The sustainable farmer included some rye in his rotation. However, since the inputs used and returns from this crop were similar to those of a second wheat crop, it has been included as wheat for simplicity. The remaining rotations are adaptations according to what the farmers said they might do if input and/or output prices changed.

Table 8.2: Rotations under sustainable and conventional farm management

Year	Sustainable				Conventional			
	1	2	3	4	1	2	3	4
1	w	w	w	w	w	w	w	w
2	w	o	w	w	o	o	e	e
3	p	p	o	o	p	p	w	w
4	p	p	p	p	p	p	o	o
5	p	p	p	p	p	p	p	p
6	p	p	p	p	w		p	p
7	p	p	p	p	p			w
8	p	p	p	p	p			o
9	w	w		w	w			o
10	o	o		o	p			p
11	p	o		o	p			p
12	p	p		p				
13	p	p		p				
14	p	p		p				
15	p	p		p				
16	p	p		p				
17		p						

w = wheat o = oats e = peas p = pasture

Rotations 1 and 2 are similar in cropping, with an emphasis on livestock in rotation 2. This includes increased area in oats, and fertiliser application on arable non-cropped area. In rotations 3 and 4 the cropping rate is increased as compared to rotations 1 and 2, with an emphasis on stock in rotation 4.

Table 8.3: Percentage of arable area in crop and under pasture with different rotation systems

	Rotation							
	1		2		3		4	
	Sust	Conv	Sust	Conv	Sust	Conv	Sust	Conv
Wheat (year 1)	13	27	12	20	13	17	13	18
Wheat (year 2)	6	0	0	0	12	17	6	9
Oats	6	9	18	20	12	17	19	27
Peas	0	0	0	0	0	17	0	9
Pasture	75	64	71	60	62	33	62	37

Sust = Sustainable   Conv = Conventional

The number of rotations included is based on the need for keeping the computations within manageable proportions for the purpose of the thesis. They are considered sufficiently diverse to enable the assessment of likely responses to policy changes.

8.4 Results

The model was run to find responses in input use and effects on returns to farming to changes in prices of fertiliser, pesticides and wheat and livestock prices. They are discussed in turn.

8.4.1 Fertiliser price

The effects of changes in fertiliser prices on fertiliser and pesticide use (both through changes in rotation and in fertiliser rates) are shown in Table 8.4. Entries under 'fertiliser prices' are those prices at which a switch in rotation or in fertiliser level within a rotation occurs. The values were obtained by parameterising fertiliser prices in the LP run.

This means that the model determines the price of fertiliser at which a change in rotation system or fertiliser rate occurs.

For the sustainable farmer a subsidy of over 20 per cent, decreasing the price of rock phosphate to under $72 per tonne, would induce the farmer to increase the amount of fertiliser used per hectare by 17 per cent. This increases the total amount of rock phosphate used from 63.0 to 73.5 tonnes on that farm. Although this indicates an almost elastic demand at that point, it is important to realise that the elasticity calculated at that point is for a large part dependent on what the actual fertiliser price is. For example, if the actual fertiliser price had been $110 per tonne, the 17 per cent increase in fertiliser use would have been brought about by a price decrease of $39 or 35 per cent. According to this model, the optimum strategy for the farmer at actual fertiliser prices ($90 per tonne) is to have a short rotation with the emphasis on livestock (rotation 4). A reduction in rock phosphate used would be brought about by a tax of 63 per cent or $57 per tonne, with a resulting drop to 42.0 tonnes of fertiliser used in total. In that rotation the pesticide expenditure is reduced from $466 to $351. The next change in fertiliser rate occurs when the fertiliser price is raised by another $101, or 176 per cent of the actual price. The total quantity used drops to 35.0 tonnes of rock phosphate, and the expenditure on pesticide remains on $351.

With wheat prices of $150 per tonne (which is the actual price received by the particular farmer) the transition from rotation 4 to 1 (which is what the farmer is actually carrying out at present) is made when the price of rock phosphate is $118, or 31 per cent higher than the actual price.

A smaller relative reduction in fertiliser price (10 per cent) is needed for the conventional farmer to increase the fertiliser rate by 17 percent, and total fertiliser used by 2 tonnes to 17.5 tonnes, although the absolute amount is larger ($38 per tonne). (As with the sustainable farmer, the observation regarding the importance of the actual fertiliser price and the effect of a change in quantity used following a price change is pertinent.) When the fertiliser price is dropped by over 45 per cent ($181 per tonne), the farmer would switch to the cropping-intensive rotation 4. This would, in addition to considerably increasing the total use of fertiliser, also increase the expenditure on pesticides by over $2000 or 45 per cent. A decrease in fertiliser use per hectare in the rotation is brought about by a price increase of 73 per cent or $290 per tonne, causing the total fertiliser use to drop to 12.6 tonnes (or by 18 per cent).

Table 8.4: Fertiliser price, fertiliser and pesticide use and returns

Fertiliser Price		Rotation	Fertiliser Use			Pest. Use**	Returns
($/t)	(%)*		(kgs/ha)	(%)#	(tonnes)	($)	($'000)
Sustainable:							
0	-100	4	280	+17	73.5	466	46.5
72	-20	4	240	0	63.0	466	41.3
90	**0**	**4**	**240**	**0**	**63.0**	**466**	**40.2**
147	+63	1	240	0	42.0	351	36.5
248	+176	1	200	-17	35.0	351	32.3
400	+344	1	160	-33	28.0	351	27.0
550	+511	1	120	-50	21.0	351	22.8
Conventional:							
0	-100	4	70	+17	56.0	6757	50.3
145	-64	4	60	0	47.6	6757	42.2
219	-45	1	70	+17	17.5	4669	38.7
362	-10	1	60	0	15.4	4669	36.2
400	**0**	**1**	**60**	**0**	**15.4**	**4669**	**35.6**
690	+73	1	50	-17	12.6	4669	31.2
1484	+271	1	40	-33	10.5	4669	21.1
1533	+283	1	30	-50	7.7	4669	20.6

* Difference between fertiliser price quoted and actual fertiliser price

\# Difference in fertiliser used per hectare between quoted and actual price

** Pesticides include all biocides used in the production process, such as weedicides, insecticides, fungicides, and veterinary chemicals

Recent fertiliser bounties, terminated in July 1988, were allocated according to the available (that is, water-soluble) phosphate content of the fertilisers. This means that those sustainable farmers who applied rock phosphate did not qualify for any subsidies. Conventional farmers who used synthetic fertilisers with the highest available phosphates, and therefore with the highest potential damage to the environment, received the highest subsidies. This amounted to $188 per tonne of phosphates for those fertilisers with an available phosphate rate higher than 15 per cent. This would have amounted to $41 per tonne for Starter 12. The results in this analysis suggest that the removal of the subsidy would affect fertiliser use on farms with conditions similar to those in the model.

8. 4.2 Pesticide price

Taxes on pesticides do not change the desirability of particular rotations (see Table 8.5).

Table 8.5: Pesticide price, fertiliser and pesticide use and returns

Pesticide Price		Rotation	Fertiliser Use			Pest. Use**		Returns
($/kg)	(%)*		(kgs/ha)	(%)#	(tonnes)	Level	($)	$'000)
<u>Conventional:</u>								
0	-100	1	60	0	15.4	3	2327	37.9
43.83	**0**	**1**	**60**	**0**	**15.4**	**3**	**4659**	**35.6**
59.89	+37	1	60	0	15.4	2	4717	34.8
181.42	+314	1	60	0	15.4	1	7153	29.9

* Difference between pesticide price quoted and actual pesticide price

\# Difference in fertiliser used per hectare between quoted and actual price

** Pesticides include all biocides used in the production process, such as weedicides, insecticides, fungicides, and veterinary chemicals

With the pesticide response specified in Section 8.3.3.3, the highest amount of pesticide would be used until the price reached 37 per cent above the actual price. At that point the farmer would use three quarters of the recommended rate, and suffer losses in returns according to the specified yield response function and increase in price. A reduction of pesticide use of 50 per cent of the actual rate is only implemented with a price increase of over 300 per cent. The farmer cuts out cropping altogether when the pesticide price reaches $1206 per kg of active ingredient.

Reduction in pesticide use below the recommended level, however, is not legal in all States in Australia. In New South Wales, for example, the minimum legal rate is the rate recommended on the container, with penalties of non-compliance of up to $20,000 (Pannell 1989b).

8.4.3 Output prices

In Tables 8.6 and 8.7 the same variables as in Table 8.4 are shown for changes in output prices. Table 8.6 refers to the sustainable farmer and Table 8.7 to the conventional farmer.

Prices were varied $10 and $20 higher and lower than the base, discussed in Section 8.3.2. The effects on the rotation, fertiliser rate, total fertiliser and pesticides used, and the financial returns are assessed.

For both the sustainable and the conventional farmer the main effect of changes in wheat prices is a change in returns. The exception is where wheat prices for the conventional farmer reach the highest level ($120 per tonne). At this price an extra 10 kgs of fertiliser per hectare would be applied. Consequently, the total amount of fertiliser used is increased by almost two tonnes per year.

With variations in wheat prices the financial returns on the sustainable farm varies between $34,600 and $45,700, which is a variation of 14 per cent on either side of the return with the base price. On the conventional farm comparable figures are $26,500 and $44,900, a variation of 26 per cent on either side of the returns obtainable with normal wheat prices. This indicates that variations in wheat prices might have a more destabilising effect on conventional farms than on sustainable farms. This is because conventional farmers are cropping more intensively than sustainable farmers.

Table 8.6: Effect of changes in output prices on fertiliser and pesticide use and on returns on a sustainable farm

Output Price	Rotation	Fertiliser Use		Pest. Use*	Returns
($/t)		(kgs/ha)	(tonnes)	($)	($'000)
<u>Wheat:</u>					
110	4	240	63.0	466	34.6
120	4	240	63.0	466	37.4
130	**4**	**240**	**63.0**	**466**	**40.2**
140	4	240	63.0	466	42.9
150	4	240	63.0	466	45.7
<u>Livestock</u>:					
20 % decrease:	1	280	49.0	351	28.1
20 % increase:	4	240	63.0	466	54.2
<u>Wheat and livestock</u>					
Wheat: $110					
Livestock:					
20 % decr.:	1	240	42.0	351	21.9
20 % incr.:	4	240	63.0	466	48.7
Wheat: $150					
Livestock:					
20% decr.:	1	280	49.0	351	34.3
20% incr.:	4	240	63.0	466	59.7

* Pesticides include all biocides used in the production process, such as weedicides, insecticides, fungicides, and veterinary chemicals

Table 8.7: Effect of changes in output prices on fertiliser and pesticide use and on returns on a conventional farm

Output Price	Rotation	Fertiliser Use		Pest. Use*	Returns
($/t)		(kgs/ha)	(tonnes)	($)	($'000)
Wheat:					
80	1	60	15.4	4669	26.5
90	1	60	15.4	4669	31.1
100	**1**	**60**	**15.4**	**4669**	**35.6**
110	1	60	15.4	4669	40.2
120	1	70	17.5	4669	44.9
Livestock:					
20 % decrease:	1	60	15.4	4669	26.1
20 % increase:	1	60	15.4	4669	45.1
Wheat and livestock					
Wheat: $80					
Livestock:					
20 % decr.:	1	60	15.4	4669	17.0
20 % incr.:	4	50	39.9	6757	36.5
Wheat: $120					
Livestock:					
20% decr.:	1	60	17.5	4669	35.4
20% incr.:	1	60	17.5	4669	54.4

* Pesticides include all biocides used in the production process, such as weedicides, insecticides, fungicides, and veterinary chemicals

Sustainable farmers who sell wheat in the organic market might incur increased wheat marketing costs (see Chapter 7), thereby reducing their output price. Changes in rotations and fertiliser rate, however, are not likely within the range examined in this chapter (between $110 and $150 per tonne), indicating that increased marketing costs transfer income away from sustainable farmers.

The effects of changes in prices for livestock products (wool and meat) were also explored. Prices were increased or decreased by 20 per cent. A decrease in livestock prices causes the sustainable farmer to change towards a rotation with less intensive stocking together with a low cropping sequence (rotation 1). This results in a decreased use of 14 tonnes of rock phosphates and $115 worth of pesticides. The conventional farmer only changes rotation (from 1 to 4) when a fall in wheat and a rise in livestock prices occur simultaneously. This results in a considerable increase in fertiliser and pesticide use (an increase of 159 and 45 per cent, respectively).

8.5 Conclusions and Qualifications

With present policies, and assuming output prices as discussed in Section 8.3.2, the most profitable management strategy for the sustainable farmer is to adopt the rotation with a relatively high cropping and stocking intensity (rotation 4). For the conventional farmer the low cropping and stocking intensity rotation (1) is optimal.

Negative externalities from the use of synthetic fertilisers can be decreased by encouraging conventional farmers to use less fertilisers or to convert to sustainable farming. This can be achieved by taxing fertilisers used on conventional farms. However, these taxes need to be considerable. A price increase of 73 per cent (or $290 per tonne) causes a decrease of fertiliser use by 17 per cent and of returns by 12 per cent ($4,400).

Ten out of the 13 conventional farmers said they would practise sustainable agriculture if returns from the two farming systems were equal. Assuming they were farming sustainably, on average they would be willing to forego $4,600 to stay with the sustainable system (see Section 5.4.4). This amount is similar to the decrease in returns to farming if fertiliser prices were increased by 73 per cent. Since none of these farmers is practising sustainable agriculture, they must consider the difference in returns from these two system to be at least $4,600. An increase in tax on fertiliser by 73 per cent is therefore more likely to affect a change in fertiliser use than a change in farm management system.

Extensive discouragement of the use of pesticides is not likely to be achieved by taxing pesticides, at least not in this industry. Only heavy taxes effect a reduction in the use of pesticides: a price increase of 37 per cent decreases the use by 25 per cent, and a 4-fold increase lowers it by half.

Negative externalities from conventional farming increase if stock prices rise while wheat prices fall. In such a case conventional farmers move towards a higher cropping intensity rotation with an emphasis on stocking, using more fertilisers and pesticides.

In the range of wheat prices explored in this model, increases in the price of organic wheat affect the revenue of organic farmers, but not the choice of rotation or the fertiliser rate.

There are a number of refinements that could be made to the model. First, the model is essentially static, with the dynamics being limited to the various agronomic effects that are captured in the specifications of the rotations. A multiperiod model would allow a more accurate specification of some of the activities which take place on a farm, in particular investment activities. The rotations specified here are determined exogenously. It would be more satisfactory if they could be determined within the model (the solutions greatly depend upon the available rotations). Endogenising the sequence of activities over time would involve, however, a considerable increase in complexity. The model results are likely to be sensitive to the fertiliser and pesticide response function. Alternative functional forms may generate different results.

9 POLICY IMPLICATIONS[14]

9.1 Introduction

With potential private net benefits from sustainable cereal/livestock farming seemingly equal to those of conventional farming in parts of south-eastern Australia (Chapter 5), and the net external effects of moving towards sustainable agriculture likely to be positive (Chapter 4), such a movement might well increase social welfare. Does this mean that there is an economic case for government to encourage sustainable farming? If there is, what policies would be appropriate? Several policies for encouraging sustainable farming are considered below. The reality that government intervention may bring its own problems must be recognised. The general problem of inefficiencies arising from government intervention (see, for example, Wolf (1979)) is not considered further. The distortions involved in revenue (Findlay and Jones 1982) is discussed further later.

9.2 Synthetic Fertilisers and Pesticides

External environmental and health costs resulting from use of synthetic fertilisers and pesticides in agriculture are instances of non-point pollution; the contributions of individual farmers to those costs are unknown. This rules out the first-best policy of taxing polluting farmers according to the external damage they cause. The best feasible policy depends on the circumstances of the case, and may involve fiscal measures or regulation (e.g. Chisholm, 1987). Internalisation of externalities from synthetic fertilisers and pesticides requires, however, that use of these inputs be directly or indirectly taxed[15].

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[14] See footnote 6.

[15] The optimal rate of tax will vary with physical conditions, management practices and other factors influencing the external damage arising from use of pesticides. The rule of one price and the Australian Constitution both prevent varying the tax on pesticide purchases with the external damage caused by use of the pesticide in the purchaser's situation, even if that were known. To improve upon the crude approach of taxing all use of a pesticide at a uniform rate, taxes, subsidies or regulations could be applied to other inputs or practices which influence the external costs of using the pesticides. However, lack of information may make it difficult to set up and administer an approach that was superior to a crude uniform tax on pesticides.

While it is unclear which approach would be most effective for making farmers pay the social costs of synthetic fertilisers and pesticides use, it is clear that the longstanding Australian policy of subsidising the use of phosphatic and nitrogenous fertilisers, terminated in July 1988, was inconsistent with that objective. Sustainable farmers did not receive a subsidy for their alternative source of nutrients (for example rock phosphate). In this way sustainable farmers were disadvantaged compared to many conventional farmers.

The policy of subsidising use of fertilisers is widely acknowledged to cause inefficiencies in the use of inputs and in the mix of conventional agricultural outputs produced (see, for example, Rose et al. 1984). The disincentive provided to the development and use of alternative agricultural systems that economise on fertiliser inputs, including systems that dispense with them totally, is an additional source of inefficiency in fertiliser subsidy policies. It is unlikely that equal treatment of the two farming systems was a consideration in abolishing the subsidies. With governments in Australia showing increased interest in sustainable agriculture, it is important to recognise the discrimination against this system of any re-introduction of fertiliser subsidies in the future.

Although pesticides do not attract a subsidy, it is likely that not all the costs of this input are paid for by farmers (Chapter 2), and that society subsidises pesticide use indirectly by being subject to negative external effects. The result is a further distortion of resource use away from sustainable agriculture. No subsidy is provided, however, on the substantial costs incurred by sustainable farmers in finding out about, and in using, such means as crop rotations, choice of crop varieties and timing of planting for the purpose of controlling pests. Tariffs, which raise prices, apply to pesticides in Australia. They were decreased from 30 to 15 per cent (nominal rate) in 1987 (Department of Primary Industry 1987b). Although tariffs are not instituted to reflect the external costs of using an input (and are not first-best for that purpose), that objective can be achieved if the increase in price reflects the external cost. However, if the increase in input price is less than the external cost, conventional farmers still have an efficiency-reducing advantage over sustainable farmers.

In Sweden taxes are levied on the use of pesticides to make farmers take account of external costs of their use. It is not clear how the size of the tax is determined (Eitjes and De Haan 1987).

An additional advantage of taxing the use of synthetic fertilisers and pesticides should be mentioned. When taxes are introduced which internalise external diseconomies, revenue is raised without the deadweight costs that characterise taxes used primarily to raise revenue (for example, Findlay and Jones 1982). In fact, by generating government revenue, a tax which corrects an external diseconomy allows reductions in other distortion-creating taxes; this improves the prospect of a net efficiency gain from a tax on use of synthetic fertilisers and pesticides from agriculture.

9.3 Information

9.3.1 Producers

In terms of the public interest or market failure justification for government intervention, a role can be seen for government in extension activities for sustainable farming. Efficiency may be increased by policies which reduce the substantial gap between the knowledge that exists on sustainable farming and the knowledge possessed by practitioners and potential practitioners of this form of agriculture. The possibility of achieving national benefits in excess of the costs from extension programs that improve know-how on sustainable farming is enhanced by the external benefits that exist in both production and consumption from a shift towards this type of agriculture. Establishing the precise form of extension program that would be most effective would require careful consideration. The case for a government role in improving information on sustainable farming would be weakened, but not necessarily removed, with internalisation of external diseconomies of synthetic fertilisers and pesticides use and of externalities in the pricing of health services.

The traditional case for public sector involvement in research rests mainly on the public good nature of findings and on other external economies arising from research. These considerations apply to research oriented to sustainable farming, as well as to that directed towards conventional agriculture and other areas.

There is, however, a basis in technical considerations for expecting sustainable agriculture to be under-researched relative to conventional agriculture. This is the seemingly greater relative importance of physical input-demanding practices in conventional farming as opposed to knowledge-demanding practices in sustainable agriculture (Section 3.5.4.3.1). At present, most Australian research is oriented to conventional farming, while little research is useful to sustainable farmers. An increase in research into sustainable agriculture could be expected if externalities in the use of synthetic fertilisers and pesticides were removed, thereby enhancing the relative profitability of sustainable agriculture. Similarly, an increase in the demand for 'healthy' food upon removal of the subsidy for health services would be expected to induce extra research into sustainable farming. If the externalities arising from use of synthetic fertilisers and pesticides in agriculture and from underpricing of health services are not removed, the economic case for intervention in research is strengthened. Such intervention might be directed to reducing externalities in conventional agriculture (for example, by the development of less harmful pesticides) as well as research into sustainable farming. Perhaps research into the transition process from conventional to sustainable farming merits high priority.

In summary, while a full discussion of research issues cannot be given here, it is suggested that research directed to sustainable agriculture is underfunded relative to research for conventional agriculture. Key reasons for this suggestion are the minimal allocation of resources to sustainable farming, together with the existence of uncorrected diseconomies in conventional agriculture and in health services, and the greater difficulty of exerting property rights over research useful to sustainable agriculture.

9.3.2 Consumers

The health benefits from the consumption of food produced on sustainable farms are likely to arise not only from reduced synthetic fertilisers and pesticide residues, but also from improved nutritional quality (Chapter 3). Reducing the use of synthetic fertilisers and pesticides in agriculture, for example by taxing synthetic fertilisers and pesticides, can be expected to improve health in both ways. However, there may be an economic case for action to promote directly the consumption of healthy food - not confined to food from sustainable farms - and balanced diets. One case is provided by consumers' deficient information on the private benefits from eating good quality food and a balanced diet. The first-best policy for doing this is not a subsidy on 'healthy' food - which encourages extra consumption by people already eating a good diet as well as those eating poorly - but provision of information. This policy would be neutral between domestic and imported food. If the externality due to pricing of health services is not removed (its removal being a first-best policy) the prospect for increasing economic efficiency with an information program - or a subsidy on healthy food - is enhanced. No attempt is made here to assess the adequacy of existing consumer information programs.

9.4 Marketing

Marketing arrangements for agricultural products can restrict the opportunities available to sustainable farmers. Would-be consumers of the organic product are also disadvantaged by being denied the product of their choice. In Australia, it is compulsory to market some produce via marketing boards (Chapter 7). These mostly do not differentiate between produce from sustainable and conventional agriculture. Abolishing such regulations should be considered.

Government regulations requiring the application of pesticides before interstate import hinder the marketing of sustainable produce. For example, fruit from Queensland and Northern New South Wales cannot be imported into other States without a certificate stating that it has been dipped or fumigated against the fruit fly. (Victoria is the only State where, at a cost, a 100 per cent physical sampling by the Department of Agriculture is allowed to substitute for treatment with synthetic pesticides.) Such goods might no longer be bought for the premium price they would otherwise command. Alternative solutions should be considered.

Because buyers cannot differentiate between sustainable and conventional produce, control of standards is needed in the production and distribution stages. Costs associated with such control can be considerable (see Wynen 1989c). As social benefits from consumption of healthy food exceed private benefits, there is a case for government to take responsibility for implementing these standards.

9.5 Establishment Costs

Conversion from conventional to sustainable farming can cause several problems (Chapter 6). Research into the transition phase would allow better-informed decisions on adoption of sustainable farming. However, there appears to be no reason for thinking that the private costs of establishing sustainable farming exceed the social costs. Hence, while the adjustment costs retard the establishment of sustainable farming, they do not provide a first-best case for government intervention. More efficient ways of promoting sustainable farming should be considered before second, third or n-th best policies of subsidising establishment costs.

In Denmark subsidies for adoption of organic agriculture were introduced in 1987 (Anon. 1987).

9.6 Conclusion

The net benefits from a movement towards sustainable farming include several categories of externalities, while the costs of such a move are mainly privately borne. The survey results indicate that private financial net benefits from sustainable cereal/livestock farming in a steady-state situation in parts of south-eastern Australia could be similar to those from conventional farming. There are costs of transferring to sustainable farming which reduce the likelihood that people farming conventionally will change over. Research could reduce those costs. Several policies for achieving an efficiency-increasing movement of resources to sustainable farming were considered. The most clearcut policy recommendations are the non-subsidisation of synthetic fertilisers, and the introduction of a tax on the use of this input and on pesticides to reflect the external costs they cause. These actions would promote efficiency-increasing cut-backs in the use of synthetic fertilisers and pesticides by farmers remaining in conventional agriculture, as well as removing efficiency-reducing barriers to adopting sustainable farming. The prospect of a net increase in efficiency from this policy is increased because it would allow reductions in other revenue-raising taxes which generate marginal social costs. There is reason to think that economic efficiency would be increased by the allocation of extra resources to research and extension activities helpful to sustainable farming. There is an economic case for government to take responsibility for implementing quality control measures for sustainable produce. Subsidising establishment costs of sustainable farming is considered least desirable.

10 CONCLUSIONS

10.1 Summary

A major point in this thesis is that, although productivity of some agricultural inputs (such as land and labour) has increased greatly in the past due to conventional agricultural methods, considerable problems (such as with pest resistance to pesticides, human health, and soil and water quality) are intrinsic in this management system. The problems are such that the question arises whether it is socially desirable to adopt an alternative form of agriculture in which these problems do not occur.

Enough sustainable producers exist for researchers in the western world to get a glimpse of what the alternative considered in this thesis, sustainable agriculture, offers. The knowledge gathered from these producers is in the area of biological possibilities, financial returns and non-financial rewards and costs, and problems with implementing or continuing with the sustainable management method.

The first indications (which became available more than a decade ago) are that sustainable agriculture is not nearly as financially disastrous at the farm level as what was often believed. This is true despite the fact that the costs of inputs in conventional farming are based on different premises than of those used in sustainable agriculture. A subsidy on synthetic fertilisers (only used by conventional farmers) in the past in Australia is the most obvious example of differential treatment of practitioners of the two systems. The absence of a tax on the use of pesticides, and the existance of government-funded research into issues of importance to conventional producers, are equally relevant in this connection. This compares with no subsidies for inputs important in sustainable agriculture (especially for research and extension). In addition, policies which keep price premiums for organic produce down prevent consumer preferences from being well reflected in the market signals observed by the (potential) sustainable farmer. Each of the above (direct or indirect subsidies for inputs used in conventional agriculture; artificially low prices for organic produce) has consequences for the rate of adoption of the sustainable farming system.

10.2. Suggestions for Further Research

Although it is clear that considerable negative externalities attach to conventional farming, research into the extent has only been carried out by a few. This might be partly due to the fact that quantifying the external effects of conventional agriculture is fraught with difficulties, such as the effects on human health (both in physical and economic terms). Research in which the external costs and benefits of conventional farming are scrutinised as compared to an alternative should enable estimation of the desirability and possibly the degree of urgency of research into sustainable options.

If a rechannelling of resources into issues of relevance to sustainable farming is to be productive, a considerable change in attitude is required of people at all levels of information gathering and dispersion. As sustainable agriculture is based on the whole system, a systems approach to agriculture as distinct from the reductionist approach used in conventional agriculture, is essential. It is outside the scope of this section to delve into this area more than superficially, but it is clear from the little learned from sustainable farmers that biological processes happening on those farms cannot necessarily be explained by current (conventional) knowledge. In a systems approach it is recognised that variations in climate, soil type, slope and other local conditions can be important in the use of naturally available resources such as predators and soil organisms. A more open attitude than in the past towards, for example, possibilities of interaction of facets of agriculture (both biological and social-economic) could well lead to results difficult to understand with present technology and theories.

If the transition from conventional to sustainable agriculture is costly, or perceived to be so, farmers might not convert to sustainable farming even if in the long run sustainable agriculture is as financially rewarding for farmers as conventional agriculture. At present one of the problems is the lack of knowledge about the process of converting to sustainable farming. Research into this area is essential to reduce the uncertainty about conversion costs.

Very little research has been carried out into the marketing of organic produce. As a new infra-structure needs to be set up in order to guarantee consumers the characteristics for which they are willing to pay, costs for the marketing can be considerable. Research in this area to develop an efficient system seems essential.

In summary, the areas of most pressing need for further research are considered to be: externalities from conventional agriculture; biological and socio-economic issues; transition from conventional to sustainable agriculture; and marketing arrangements.

APPENDIX 1: PRODUCTION[16]

A.1.1. Crops and mixed farming

Murphy (1975) conducted a study on three organic farms in England. Two of these farms were mixed enterprises, combining cereal growing with dairying. On the third farm only cereals were grown.

Regarding crop production, winter wheat, winter oats and spring oats were grown on one of the farms. On the other two farms winter wheat and spring barley were produced. The results of the case studies (Org.) were compared with the West Midlands National Cereals Survey (WMNCS) for the year 1972, and with those of the Cambridge Farm Management Survey (CFMS), a traditionally high yielding grain growing area, for the years 1972, 1973 and 1974. The yield data are displayed in Table A.1.1.

In 1972 the yield figures for winter wheat on the organic farms were generally somewhat lower (between 4 and 17 per cent) than on those of the comparable farms, although only marginally lower than on those of the WMNCS-farms. For 1973 and 1974 the comparison is only possible with the Cambridge Survey farms. In 1973 the gap between the two comparisons was considerably smaller, with one of the three organic farms yielding more than the CFMS-farms. In 1974 two of the organic farms yielded more than the group of farms used for comparison, while on the third organic farm the yield was approximately half of that on the other two farms. In view of the fact that in the other two years yields on the third farm were only marginally lower, it is reasonable to wonder what special circumstances applied on this farm for this particular year.

Not many data are available for winter oats. The one comparison available showed a higher yield on the organic farm than on the conventional farm.

As far as spring oats is concerned (only grown on the three farms number 1), in one of the three years (1972) the yield of that crop was lower on the organic farm than on both of the comparable groups of farms. In the other two years the yield on the organic farm was higher than on the farms

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[16] See footnote 2

of the Cambridge Survey.

Table A.1.1: Crop yields under different agricultural systems: Murphy (1975) (t/ha)

Source/ Farm type	Year	Winter wheat	Winter oats	Spring barley#
Org. 1	1972	4.2	4.7	3.4
WMNCS 1		4.3	4.5	4.1
CFMS 1		4.7		4.4
Org. 2		4.5		4.2
WMNCS 2		4.6		4.3
CFMS 2		4.7		4.2
Org. 3		4.0		4.5
WMNCS 3		4.3		3.9
CFMS 3		4.8		4.2
Org. 1	1973	4.2	4.5	4.7
CFMS 1		4.4		4.2
Org. 2		4.8		3.3
CFMS 2		4.4		4.1
Org. 3		4.0		4.3
CFMS 3		4.4		4.1
Org. 1	1974	5.0	5.2	4.3
CFMS 1##		4.7		4.1
Org. 2		4.8		4.2
CFMS 2##		4.7		4.0
Org. 3		2.5		3.5
CFMS 3##		4.7		4.0

Org. = Organic

WMNCS= West Midland National Cereals Survey

CFMS = Cambridge Farm Management Survey

= for Org. 1 and its comparisons: spring oats

= estimates

Spring barley is the crop with the most variation in the comparisons. In 1972 the yield on the organic farms was comparable or superior to the yield in the other groups. In 1973 yields on the second organic farm were relatively low, and those on the third farm relatively high, while in 1974 this situation was reversed.

In summary, yields of the four crops grown on these three farms were quite comparable to yields on conventional farms. The data of two of the three crops for which sufficient data are available (winter wheat and spring oats) suggest that some years might be more favourable for growing these crops in a sustainable way than other years (in this case 1973 and 1974). With the third crop (spring barley) no pattern is obvious.

Klepper et al. (1977) compared 14 commercial-sized organic farms with matched conventional farms in the Corn Belt (United States) for the years 1974 and 1975. All farms produced both crops and livestock, but only the crop production side of the farms was analysed '...because it is mainly in crop production that the technologies diverge' (p.2). Although this implies that no whole-farm analysis was carried out, the analysis was done for the whole of the crop side of the farms, and not for crops individually.

Since no list of organic farms existed at the time of the study, the organic farms were located mainly by word of mouth. Decisions on inclusion of farms in the survey were based on information on '...location, size, length of time the farm had been operated using organic methods, a preliminary judgment of each organic farmer's competence as a farm manager, and the resources available...'(p.2). The study should therefore be seen as a series of case studies. In most cases the organic farms had previously been operated as conventional farms, generally in the same way as the majority of similar farms in the area. The minimum time of organic management on included farms was four years, with an average of six years.

The conventional farms which served as comparisons were chosen on the basis of similarity of soil type, size, farm operations and livestock inventory. In addition, the authors asked the Agricultural Stabilisation and Conservation Service (ASCS) to recommend farmers for inclusion. All those included were 'top management' operators as judged by local ASCS personnel.

In Table A.1.2 yields of the different crops including only matched pairs are shown as 'organic 1' and 'conventional 1'. In addition, the average yields of all organic and all sampled conventional farms are shown as 'organic 2' and 'conventional 2' respectively. Average yields on conventional farms in the same counties as the organic farms are shown as 'conventional 3'. The term 'conventional 4' is used to indicate the average yields for all conventional farms in the same counties as the sampled conventional farms. The comparisons should therefore be between organic 1 and conventional 1; organic 2 and conventional 3; and conventional 2 and conventional 4.

Table A.1.2: Crop yields under different agricultural systems: Klepper et al. (1977)

Farm type	Year	Wheat (t/ha)	Oats (t/ha)
Organic 1	1974	1.9	2.5
Conventional 1		1.9	2.7
Organic 2		1.9	2.7
Conventional 2		1.9	2.7
Conventional 3		2.1	2.5
Conventional 4		1.9	2.7
Organic 1	1975	1.9	2.6
Conventional 1		2.5	2.7
Organic 2		1.7	2.5
Conventional 2		2.7	-
Conventional 3		2.5	2.6
Conventional 4		2.4	-

Organic 1 and Conventional 1 = average of only matched organic and conventional farms

Organic 2 and Conventional 2 = average of all sampled organic and conventional farms

Conventional 3 andConvential 4 = average of all conventional farms in the same counties as the sampled organic and conventional farms, respectively

The first point to notice is that the sampled conventional farms in general (conventional 2) have equal or higher yields than the average farm in the same counties (conventional 4), especially in 1975. This indicates that the conventional farms chosen for inclusion in the survey might indeed be farms which benefit from higher than average management skill.

Second, it is possible that differences exist between crops in performance on sustainable farms relative to conventional farms. For example, in this study differences in wheat yield between the two systems in 1975 were more pronounced than in oats yields. Third, relative yield performance of the two systems might well be influenced by climatic conditions. 1975 was a year with good weather conditions. The authors opined that: 'The better relative performance of the conventional farms under these conditions might reflect the greater response in yields to nutrient availability at the margin when weather conditions are favorable'(p.7).

In summary, yields for several crops on mixed farms under the different management systems in general are quite comparable. Differences between the two systems can be influenced by the particular crop or year.

The study carried out by Vine and Bateman (1981) is different from the previous two studies in that a much more extensive survey was carried out. Of the approximately 70 farms which were identified as organic, becoming organic, or semi-organic, full financial and physical records for one accounting year were obtained from about 30, with a few additional partial records. Comparisons were made between this group of farmers and with figures published by the Farm Management Survey, taking into account the region, year, type of farming and farm size. The study includes: predominantly arable farms; ley-arable farms (crops, beef and sheep; crops and dairy); and mainly pasture farms (dairy; beef and sheep). Yield figures were collected for 1977, 1978, or 1979.

Figures for yields for winter wheat and spring barley are reproduced in Table A.1.3. Out of the 11 comparisons for wheat, 6 are lower on the organic farms than on the conventional farms, 4 are similar (within the range of 0.2 t/ha), and 1 is higher. Out of 8 comparisons for spring barley 4 are lower on the organic farms than on the conventional farms, 3 are similar, and 1 is higher.

Table A.1.3: Crop yields under different agricultural systems: Vine and Bateman (1981)

Farm type#	Year	Winter wheat (t/ha)	Spring barley (t/ha)
Organic	1977	4.9	3.7
Conventional		4.8	4.6
Organic	1978	3.0	2.0
Conventional		5.6	4.0
Organic	1978	3.7	3.7
Conventional		5.6	4.0
Organic	1978	4.3	4.3
Conventional		5.7	4.4
Organic	1978	4.3	4.9
Conventional		5.3	4.0
Organic	1978	4.7	
Conventional		4.6	
Organic	1978	4.8	
Conventional		4.9	
Organic	1979	4.9	3.0
Conventional		5.3	4.0
Organic	1979	4.8	4.2
Conventional		5.4	4.3
Organic	1979	5.3	3.7
Conventional		5.1	3.8
Organic	1979	5.8	
Conventional		5.1	

Note:
Wheat and barley shown under the same farm type are not necessarily grown on the same farm

Thus, in summary, yields of winter wheat and spring barley were found in this study to be similar or somewhat lower than the standard with which they were compared.

Conacher and Conacher (1982) carried out a survey of organic farmers, mainly in Western Australia. The data collected were based predominantly on farmers' perceptions and should therefore be treated carefully. The answers were recorded for three different groups of enterprises: grains/ sheep, beef/ dairy/ pigs, and horticulture/ market gardens/ orchards/ vineyards. The survey covered 50 farmers. Questions put to farmers are repeated here. In order to avoid repetition of questions in the next section (in which the beef/dairy/pigs enterprises are discussed), the answers of all farmers (including those in the livestock-only sector) are supplied here.

Asked to compare the yield with that of conventional farmers, the largest group of the answers (20) was recorded as 'don't know/too early'. 15 answers indicated a higher yield, 12 answers an equal yield and 10 lower (some farmers had more than one enterprise). There was a distinct difference in answers between the different enterprises. In the third group, horticulture/market gardens/orchards/vineyards, about half of the answers indicated higher yields for the organic enterprise than for the conventional neighbours. The rest of the answers were 'the same' (2), 'lower' (2) and 'don't know/ too early' (4). For the grains/sheep enterprises a similar number of answers was recorded for each possible group of answers. Almost two thirds of the category of the beef/dairy/pigs farmers did not have an opinion on the matter. No farmers in that group felt that they had a higher yield than their neighbours.

A question comparing the yields of the organic farm with the yields of the same farm before transition to organic farming was also asked. Of the answers received, most (14) indicated that they did not know, or that it was too early to tell, 7 felt they had higher yields under the present (organic) system, 3 the same, and 10 lower.

The authors also tried to get an idea about the initial drop in yields on farms converting from conventional to sustainable. (The US Department of

Agriculture (1980) reported this occurence in the transition period). At the question: 'Was there an initial drop in yields after converting to organic farming methods', 14 answered 'yes', 1 'no', 9 'no change', while 10 did not know, or had not answered the question.

Gunning and Cullen (1983), in their study of six biological farms in New Zealand, reported upon soil fertility, structure and fauna; stock health; insect and weed problems; and sward composition. For the soil variables some tests were done. The others were recorded as discussed with the grower, or as observed on the farm. Results can therefore be regarded as subjective. Although in this survey no particular emphasis was put on the quantity produced, it still seems appropriate to report this study here.

Although the soil phosphorus and potassium levels were generally low on the biological farms (p.1) as compared to the conventional farms, the nitrogen level was found to be equal or higher (p.4). Soil structure seemed to have improved under the biological farming system, while no difference in biological activity and size of biomass was recorded on those enterprises (p.4). Stock health was reported to be better on the biological farms than on the neighbouring farms. Pasture pests and weeds, and sward composition did not seem to be different between the two systems. The vigour of clover appeared to be 'below optimum' (p.4) on the sustainable farms.

A.1.2. Livestock

The most extensive data available regarding yields from livestock pertain to dairy farming. Of the three studies mentioned here, two are concerned with dairy (Murphy 1975; Cleveringa 1978), and one with 'mainly pasture' farming, including dairy, sheep and beef (Vine and Bateman 1981).

The two organic dairy farms analysed by Murphy (1975) were compared with conventional farms with average herds of the same breed (Conv.:breed); with an average herd in the same location (Conv.:location); with farms of the same size (Conv.:size); and with farms in a low cost milk production scheme (LCP), which was operated by the Milk Marketing Board (for the results see Table A.1.4). Figures for the organic farms and their comparison were available for 1973. For that year the four comparisons of the first farm showed that the technical performance of the organic farm was high. Yields per cow and stocking rates were higher than on the other farms. On farms of the only group where both concentrates fed per unit of milk and added soil nutrient were recorded, these measurements were somewhat lower and considerably higher, respectively, than on the organic farm. It is therefore likely that the net yield (defined in Chapter 4) per hectare on the organic farm was considerably higher than on the conventional farm. On the second farm the yield per cow and the concentrates fed per cow were (marginally) lower than those on the conventional farms, while the stocking rate was somewhat higher. This resulted in the milk yield per hectare being higher on the organic farm than on the comparisons. If equal or less soil nutrients were imported onto the organic farm than on the comparisons (which is a reasonable assumption) the net yields on the organic farm must have been higher.

Table A.1.4: Measures of productivity of dairy farming under different agricultural systems: Murphy (1975)

Farm type	Area	Cows	Stock	Additional Feed	Soil Nutrients	Yield
	Ha	No.	Units per forage ha	Kgs per litre milk	£ per forage ha	Litres per cow
Organic 1	120	250	2.35	0.36	7	4740
Conv.:breed			1.75	0.33		3864
Conv.:location			1.70	0.32		4072
Conv.:size >120			1.84	0.34	24	4358
LCP			2.20	0.36		4100
Organic 2			2.52	0.33	1	3028
Conv.:breed			2.17	0.38		3228
LCP			2.04	0.39		3192

Conv. = Conventional; LCP = Low Cost Milk Production Survey

Cleveringa (1978) compared a sustainable dairy farm in the northern part of The Netherlands with four groups of conventional farms (see Table A.1.5). The first group was similar to the sustainable farm in that it had approximately the same number of cows (Conv.:no.cows), and the second group had a similar acreage (Conv.:ha) as the farm under investigation. These two groups of farms were in the same area as the sustainable farm, with the same soil type. The years of study were 1974, 1975, and 1976. The other two groups of farms were chosen on the basis of their superior performance, both in connection with production and with technical and financial parameters. In order to be able to include a sufficient number of farms for comparison, the location of these farms was not restricted to the same location as the sustainable farm. This may mean that the physical environment, for example soil, was less homogeneous than in the first two groups. The group of farms with one operator is indicated in the tables as 'Management 1', while the term 'Management 2' is used for farms with two operators.

For all three years examined, the stocking rate ('Stock'), 'imported' feed ('Additional Feed') and fertilisers ('Soil Nutrients'), and the yield were lower on the organic farm than on the four groups of farms with which it was compared. However, it is quite possible that the net yield on the organic farm was similar to that of the other farms. Several authorities in agricultural research were investigating this particular aspect at the time of the report.

The year 1976 was very dry. It would have been interesting to see whether the results of the comparison were similar to those of Klepper et al. (1977) under climatically adverse conditions. However, the production in the other groups of farms increased in that year as compared to the previous year, while on the sustainable farm the production decreased. The author attributes this to a difference in use of technology, in this case the use of irrigation. In 1976 irrigation was used on many farms in The Netherlands. Although also used on the sustainable farm in that year, it occurred at a late stage, when the effect of irrigation was only noticed after production had decreased to a very low level. The policy of supplementing the home production of feed with a minimal amount of bought concentrates also was adhered to until late in the season. Although the total amount imported on the sustainable farm doubled as compared to the previous year, the other two groups also doubled their intake, which resulted in a considerably higher extra amount being bought on the conventional farms. The combination of these two policies on the sustainable farm culminated not only in low yields at the time of the drought but also afterwards, during the rest of the lactation period.

Table A.1.5: Measures of productivity of dairy farming under different agricultural systems: Cleveringa(1978)

Farm type/ Year	Area	Cows	Stock	Addit. Feed	Soil Nutrients	Yield	
	Ha	No.	Units/ forage ha	Fl./ cow	Fl./ forage ha	Litres/ cow	Litres/ forage ha
1974							
Organic	45	53	1.75	363	16	4494	5290
Conv.:no.cows	28	44	2.15	684	290	4658	7415
Conv.:ha	39	73	2.44	751	339	4701	8707
1975							
Organic	45	55	1.74	479	0	4848	5867
Conv.:no.cows	30	50	2.71	829	310	4903	8173
Conv.:ha	47	94	2.62	979	370	5217	10432
Management 1	30	71	3.01	997	445	5528	13762
Management 2	47	102	2.96	982	413	5473	13057
1976							
Organic	45	55	1.78	686	0	4574	5566
Conv.:no.cows	31	56	2.30	1154	383	5059	9116
Conv.:ha	46	92	2.55	1265	436	5301	10716
Management 1	30	71	3.05	1364	441	5527	13810
Management 2	47	110	3.01	1312	452	5550	13775

Addit. Feed : Additional Feed

Fl : Dutch guilder = $1.681: 23 June 1989

Vine and Bateman (1981, p.89) reported on livestock output per adjusted forage hectare for the 'mainly pasture' farms. On the 13 farms surveyed, this measure ranged between 26 and 121 per cent of that of the standard, with 9 farms below 70 per cent, and 2 farms equal to, or higher than, 100 per cent. In general, the use of concentrate per unit of stock was lower on organic farms than on conventional farms. Also the expenditure on soil nutrients (measured on the whole farm) was lower on those farms.

APPENDIX 2: QUALITY OF FARM PRODUCTS[17]

Details of the work on product quality as described by Balfour (1975) are as follows.

A farm of 216 acres was divided into three farms in such a way that variations in different variables (such as soil and aspect) were similar represented in all three. Two farms, of equal size, had at least three species of farm livestock and the third farm, which was somewhat smaller, was stockless. Seed was provided for each farm to establish the first crop only, with subsequent needs for seed to be covered by own production. The original livestock was also supplied from a common source, and had to be replaced by home bred stock. Variations in the herd due to hereditary factors were kept to a minimum.

The first farm received only those plant and animal residues produced on that particular part of the property. The second section got the same plus a standard application of synthetic fertilisers. And the third section received the plant residues it produced plus fertiliser, but no animal manures.

The objective of the research was to study the possibility of a balanced agricultural system. To accomplish this, nothing was imported on any of the enterprises, apart from the fertilisers and pesticides on the mixed and stockless sections, and some dried seaweed (and later some small quantities of fishmeal for the poultry) on the organic section. In addition, no products were allowed to leave the enterprises except for the final products, that is, animal products such as milk, eggs, wool, and meat.

Results were calculated over the whole of one rotation period (1952 to 1961). The main crops grown are shown in Table A.2.1. At first sight it might seem that the data are not much different from data supplied under the 'quantity' section. However, crop production was designated for feed. The quantity of the feed produced, together with its quality, influences

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[17] See footnote 2.

livestock production. Table A.2.1 should therefore be seen as a first stage in the assessment of the final product of the two stocked sections. In the case of the stockless section the yields of the different crops were compared with those of the other two sections.

Table A.2.1: Crop yields under different agricultural systems:
Balfour (1975)

Farm type	Winter wheat	Winter oats	Spring barley	Beans	Peas
Organic	2.8	2.9	3.5	1.5	1.3
Mixed	3.3	3.0	3.4	1.7	0.9
Stockless	3.0	-	4.0	2.0	-

Although the yields of most crops were lower on the organic enterprise than on the others, the differences of many of those crops were not very large. Balfour (1975) also drew attention to the fact that the differences in yields between the enterprises did not change towards the end of the period. In a situation where two of the enterprises received nutrients from outside the farm, and the other did not, a decrease of yield over time on the farm with no outside supply of nutrients is generally expected as compared to the farms which did. Instead, soil samples over the years 1953 to 1960 indicated that after the first rotation cycle the available nitrate nitrogen and potash was higher on the organic part of the farm than on the mixed part. For phosphate this was not the case, although the available phosphate level after one whole rotation was as high as at the start of that eight year rotation.

The quality of those same crops was examined by considering the animal products resulting from the consumed feed. In Table A.2.2 some factors related to dairy cattle have been recorded for the average of 1962 to 1964. The stocking rate on the organic section ('Cow days') was lower than on the mixed section, while cattle on the first mentioned section received lower rations of concentrates. Yield per milking day was considerably higher on that part than on the mixed, conventional part of the farm. Due to the lower stocking rate on the alternative part of the farm the milk yield per hectare of the two enterprises was similar.

Table A.2.2: Measures of productivity of dairy farming under different agricultural systems: Balfour (1975)

Farm type	Stock	Additional Feed	Yield	
	Cow days	Kgs per cow day	Litres per milk day	Litres per ha
Organic	5274	1.18	9.6	1152
Mixed	5620	1.51	8.6	1128

The extra available feed enabled the keeping of approximately 25 per cent more chickens on the conventional farm than on the alternative farm, some 50 animals. The average number of eggs per chicken varied over the years, with differences between the two systems occurring in both directions. The number of eggs per unit of feed was higher on the organic section, although no mention was made of the egg weights.

Other livestock could not be reported upon, since it was decided to substitute sheep for the original pigs in 1962. The one year for which data were available showed an approximately ten per cent higher total wool clip on the organic farm than on the conventional farm.

Towards 1960 and beyond, weed and pest problems had become apparent on the conventional mixed enterprise and stockless sections. These became problems to such a degree that only the use of pesticides could save the crops from total destruction.

APPENDIX 3: GROSS AND NET MARGIN[18]

A.3.1. Crops and mixed farming

The financial results of the three cereal farms in Murphy's survey (1975) are reported in Table A.3.1. The variable costs for the organic farms 1 and 3 are mostly (considerably) lower than those of the conventional sector. With similar yield figures (see Appendix 1) and somewhat higher output prices (not shown in this table) the gross margin (produce times price minus variable costs) is generally higher for the sustainable farms. The exception is Org. 3 in 1974, which was already commented upon (Appendix 1). Although the variable costs in Org. 2 are lower than on the average of the comparable farms, the cost structure resembles that of its comparisons to a much larger degree than that of the other two sustainable farms. Even so, the gross margin of this sustainable farm is generally also higher than that of its conventional comparisons, especially in the case of winter wheat. Not many figures are available for the net margin (gross margin minus fixed costs). Comparisons can only be made for the year 1972, and give a mixed picture. Figures for winter wheat on the first organic farm indicate a relatively high net margin, while those for spring oats are relatively low. For the second farm both of the crops show a comparatively low net margin, while the last farm shows a relatively high net margin for the same crops. The main differences in fixed costs between the two groups of farms are costs of labour and machinery (not included in the table), which are consistently higher for the organic group.

An aspect of farming which is important in the overall profitability of the farm, and which is not obvious from an enterprise analysis such as the one carried out by Murphy, is the degree of diversification in the different farming systems. The net margin of the whole farm is determined by the net margin of each individual crop and the relative importance of each crop in the cropping system. This is an aspect considered in the following research.

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[18] See footnote 2.

Table A.3.1: Financial measures for some crops under different agricultural systems: Murphy (1975) (£ per ha)

	Year	Variable Costs		Gross Margin		Net Margin	
Farm type		Winter wheat	Spring barley#	Winter wheat	Spring barley#	Winter wheat	Spring barley#
Org.1	1972	9	12	168	100	81	20
WMNCS1		28	26	116	95	67	44
CFMS1		32	24	124	99		
Org.2		27	18	158	137	58	37
WMNCS2		28	26	134	115	74	55
CFMS2		32	26	124	121		
Org.3		13	12	145	149	73	66
WMNCS3		28	27	116	89	67	37
CFMS3		32	26	124	121		
Org.1	1973	20	14	317	239	227	151
CFMS1		38	28	218	152		
Org.2		33	22	352	174	231	55
CFMS2		38	31	218	174		
Org.3		16	14	277	200	199	107
CFMS3		38	31	218	174		
Org.1	1974	22	14	386	228	291	128
CFMS1##		54	35	254	186		
Org.2		39	25	350	222	217	92
CFMS2##		54	36	254	200		
Org.3		21	17	172	191	91	88
CFMS3##		54	36	254	200		

Org. = Organic
WMNCS = West Midland National Cereals Survey
CFMS = Cambridge Farm Management Survey
# = spring oats for Org. 1
= estimates

Klepper et al. (1977) multiplied the yields of the different crops by the proportion of crop land they occupied on the farm and by a uniform price, disregarding the possibilities of organic farmers being able to secure higher prices for their produce. Variable costs were calculated and these plus the resulting figures for the gross margin are shown in Table A.3.2.

The results for the two systems are similar, the gross margin being somewhat higher for organic farmers in 1974, and vice versa in 1975.

Table A.3.2: Financial measures for different crops under different agricultural systems: Klepper et al. (1977) and Lockeretz (1981) ($/ha)

Farm type	Year	Variable Costs	Gross Margin
Organic	1974	69	324
Conventional		114	314
Organic	1975	84	336
Conventional		133	346
Organic	1976	91	336
Conventional		150	333
Organic	1977	95	289
Conventional		129	278
Organic	1978	107	333
Conventional		143	384

The fixed costs, although not considered in detail, were found to be comparable for the two groups. Data on the estimated cash rental value of land and on the type and size of machinery and equipment were similar. The assumption of similarity in other fixed costs depending on these factors, such as tax and interest rates, was therefore considered to be reasonable. If this assumption is appropriate, it follows that the net margins for the organic farms surveyed were similar to those of the surveyed conventional farms.

Lockeretz (1981) expanded those figures to 1978. In this research, farmers were selected from respondents to an earlier survey, while comparisons were made with county average yield data and standardised crop production budgets. The results are similar to those in Klepper et al. (1977): the variable costs are considerably lower for organic farms than for conventional farms, while gross margins are comparable.

Vine and Bateman (1981) discussed relative gross margins in somewhat different terms. The gross margin for winter wheat and spring barley per hectare was expressed as percentages of the comparison with conventional farming, at normal prices. These values ranged from 57 to 138 percent for winter wheat with 5 of the 10 higher than 100 percent (p.87). For spring barley the range was from 53 to 135 percent, with four out of the six organic farms higher than 100 percent (p.88).

In the same study fixed costs on sustainable farms were found on average over all the different farm types to be 10 per cent below those on conventional farms, although the range was considerable (p.93). On farms with only crops and mixed enterprises, this range was between -62 and +143 per cent, with 10 out of the 15 sustainable farms having lower fixed costs than the standard.

Although gross margins for crops per hectare on sustainable farms were quite comparable to those on conventional farms, and fixed costs often were lower, net margins on sustainable farms were generally lower. This was due to the fact that net margins of livestock enterprises often were relatively low. For example, on the 14 established sustainable 'pasture and arable' farms (p.90) the net farm income from grazing livestock ranged from -126 to 912 percent of the conventional farms, with 5 sustainable farmers receiving a net farm income similar or higher than the standard.

Conacher and Conacher (1982) gathered qualitative data for the financial performance on the farm, both for crop and livestock farms. For costs, 17 organic farmers felt that their costs were lower than those of their conventional neighbours, with no farmers expressing the thought that they had the same or higher costs. For gross margins the corresponding figures were 3, 6 and 1, and for the net margin 2, 5 and 5. At the question about the current profitability compared to the situation prior to conversion from conventional to sustainable agriculture 12 answered that it was higher, 3 the same, 5 worse, and 14 'don't know' or 'too early'.

In summary, in the four studies considered in which costs were quantified, variable costs in general were lower on the sustainable farms than on the conventional farms, which generally resulted in higher gross margins on the sustainable farms. Data on fixed costs were more variable. Murphy (1975) reported them to be higher on the sustainable farms than on the conventional farms, Klepper et al. (1977) approximately equal, and Vine and Bateman (1981) lower. This resulted in net margins ranging from below to above the conventional comparisons.

There are some indications that the type of enterprise and climatic conditions, are important factors in connection with net margins. Although in Murphy's study both the cereal and dairy (see below) enterprises on sustainable farms were comparable with conventional farms, Vine and Bateman (1981) found that crops in general were more financially rewarding for sustainable producers than livestock enterprises. Klepper et al. (1977) raised the question whether crops in the sustainable system were able to withstand adverse weather conditions better than in the conventional system.

A.3.2. Livestock

In Murphy's work (1975) (Table A.3.3) it was shown that the gross margins per cow of the sustainable dairy enterprise in both case studies were higher than in all of the comparisons, bar one. The exception was the group of farms of similar size as that of Organic 1. However, due to a higher stocking rate on the sustainable farm, the gross margin per hectare on Organic 1 was also higher than on the corresponding conventional farms of similar size.

In the case of net margins the first organic farm was financially doing better than the group of farms with the same breed, but (marginally) worse than farms in the same area, and considerably worse than the farms with the same acreage. The cost savings in this last group were made especially in the area of labour per hectare (not shown in the table).

Table A.3.3: Financial measures for dairy farming under different agricultural systems: Murphy (1975)

Farmtype	Gross Margin		Net Margin
	£/cow	£/ha	£/cow
Organic 1	148	348	57
Same:breed	137	240	50
Same:loc.	135	213	60
Sim.:size	160	297	80
LCP	122	294	
Organic 2	155		47
Same:breed	110		27
LCP	110		

LCP = Low Cost Milk Production Survey

In Cleveringa's study (1978) gross margins per cow were shown to be higher on the sustainable farm than in the four groups with which it was compared (see Table A.3.4). Due to a considerably lower stocking rate, however, gross margins per hectare were lower for all three years on the sustainable farm under consideration. The fixed costs in these groups of conventional farms were considerably higher than on the sustainable farm. Excluding those farms which were chosen on the basis of management skill, the net margins for the sustainable farm as a whole were higher than on the average sampled conventional farm (these farms are dairy-only farms). This is true especially when it is considered that 1975 was the only 'normal' year (see above). However, the group made up of the best managers obtained better net margins than the sustainable farm. Financial results in this study were calculated with normal prices.

Table A.3.4: Financial measures for dairy farming under different agricultural systems: Cleveringa (1978)

Farmtype	Year	Gross Margin		Net Margin
		Fl/cow	Fl/ha	Fl/farm
Organic	1974	2282	2470	- 4649
Conv.:no.cows		1979	2662	-15930
Conv.:ha		2046	3234	- 3101
Organic	1975	2649	3003	157
Conv.:no.cows		2301	3326	-17030
Conv.:ha		2251	4026	-15760
Management 1		2282	4764	17400
Management 2		2277	4726	26300
Organic	1976	2510	2926	-27200
Conv.:no.cows		207	3219	-27193
Conv.:ha		2170	3617	-40710
Management 1		2130	4366	- 8500
Management 2		2082	4215	-20300

Fl : Dutch guilder = $1.681: 23 June 1989

The survey conducted by Vine and Bateman (1981) covered dairy and also other livestock enterprises. The gross margin per hectare of the 12 sustainable dairy or mainly dairy farms ranged between 46 and 118 per cent of the conventional farms, with 3 over the 100 per cent. Of the 14 sustainable 'livestock, cattle and sheep' farms the range was between 29 and 117, with only one farm over the 100 percent (p.78).

Although fixed costs for the 'pasture farms' were generally lower on the sustainable than on the conventional farms, net margins were also lower (p.93). Of the 12 'mainly pasture' farms, for which figures for net margins were available, net margins for grazing livestock ranged between

-188 to 104 per cent of the conventional farms, with one farm over the 100 per cent (p.90).

In summary, the figures for gross and net margins for dairy and other livestock enterprises vary in the three studies reviewed. Murphy (1975) reports higher gross margins per hectare on sustainable farms than on conventional farms, while net margins are lower in some cases and higher in others than those of the counterparts. Both Cleveringa (1978) and Vine and Bateman (1981) found gross margins and fixed costs on sustainable farms to be lower than on conventional farms, although their figures on the net margin do not show the same result. Vine and Bateman (1981) found also the net margins to be lower on the sustainable farms , while Cleveringa (1978) reported lower net margins only in the case of comparisons with selected known good-management farms. The other comparisons were favourable for the sustainable farm.

APPENDIX 4: PRELIMINARY SURVEY OF BIOLOGICAL FARMING PRACTICES IN AUSTRALIA

I am conducting a survey into the practices of biological farming in Australia.

In recent research into organic farming in Western Australia by A. and J. Conacher (Geowest No. 19, Dept. of Geography, University of W.A., 1982), the main problem with this farming practice was identified as 'lack of sound, up-to-date advice and information'. This was found to be the problem in connection with inputs such as organic fertilisers, with controlling pests and weeds, with improvements of soil fertility and with marketing of organically grown produce.

Therefore, a study which would make more information available about the advantages of and the problems with organic farming systems should be very useful. This is the case particularly in three situations:

1. An increasing awareness by governments and producers' groups of the benefits of a biological farming system should result in more emphasis on the needs of this group of agricultural producers. This could lead to e,g, research in areas of interest to organic farmers, such as biological control of weeds and insects, and to consideration of equal treatment for subsidies between biological and conventional producers (for a background article on these issues see 'Organic Growing', Vol. 10, No. 2, June 1985).
2. For farmers considering to start practising an organic farming system, an increased knowledge of benefits and costs of biological farming could be helpful.
3. To farmers who are already practising in this way, a knowledge of the different possibilities within biological farming could be very useful.

For such a study participation by a number of people is needed. At the moment I am compiling a list of all environmentally-aware farmers. My information is that you might fall into this category.

Very few farmers would classify as purely organic farmers. In question 3 a definition of organic farmers is given, after which you are asked to classify yourself. Some space is provided to clarify your classification if you so wish. In question 4 you are asked to list people you know who, in your opinion, would qualify in category 1, 2 or 3. As it is impossible to conduct the research without sufficient farmers, it would be much appreciated if you would take care to answer this question as fully as possible.

Questions 5, 6, 7 and 8 are included to provide me with some idea about the characteristics of the farm. In case I can not survey all participants, answers to these questions should enable me to determine who to contact again later.

If you are willing to participate in a further survey (question 9): it will involve a more extensive questionnaire and possibly a follow-up visit if you do not object. The results of the study will be published. Full confidentiality is guaranteed.

Even if you do not wish to participate in a more extensive survey it would be appreciated if you could fill out the questionnaire and send it back in the envelope provided.

As I will need data to conduct my research, an early reply would be most appreciated.
Thanking you in anticipation,

ELS WYNEN,
C/- SCHOOL OF ECONOMICS,
LA TROBE UNIVERSITY,
BUNDOORA, VIC., 3083.

SURVEY OF BIOLOGICAL FARMING PRACTICES IN AUSTRALIA

1. NAME:...

2. POSTAL ADDRESS:..................,.......................
.................................POSTCODE........TEL..........

3. IF 'ORGANIC' IS DEFINED AS: 'A PRODUCTION SYSTEM WHICH AVOIDS OR LARGELY EXCLUDES THE USE OF SYNTHETICALLY COMPOUNDED FERTILIZERS, PESTICIDES,GROWTH REGULATORS AND LIVESTOCK FOOD ADDITIVES. TO THE MAXIMUM EXTENT FEASIBLE, ORGANIC FARMING SYSTEMS RELY ON CROP ROTATIONS, CROP RESIDUES, ANIMAL MANURES, LEGUMES, GREEN MANURES, OFF-FARM ORGANIC WASTES, MECHANICAL CULTIVATION, MINERAL BEARING ROCKS AND ASPECTS OF BIOLOGICAL CONTROL TO MAINTAIN SOIL PRODUCTIVITY AND TILTH, TO SUPPLY PLANT NUTRIENTS AND TO CONTROL INSECTS, WEEDS AND OTHER PESTS.' (USDA 1980),

HOW WOULD YOU CLASSIFY YOURSELF? (PLEASE CIRCLE APPROPRIATE NUMBER),

```
     1           2            3           4           5           6
     !...........!............!...........!...........!............!
 ORGANIC                                                 CONVENTIONAL
```

REASON FOR CLASSIFICATION:..
....

4. DO YOU KNOW OTHER PEOPLE WHO YOU WOULD CLASSIFY AS 1, 2 OR 3 IN QUESTION 3? PLEASE ENTER PEOPLE YOU KNOW IN THIS CATEGORY.

NAME:...
ADDRESS:...
..........................POSTCODE................TEL..................

NAME:...
ADDRESS:...
..........................POSTCODE................TEL..................

(IF MORE SPACE IS NEEDED PLEASE USE OTHER SIDE OF PAPER).

5. FOR HOW MANY YEARS HAVE YOU FARMED ORGANICALLY? ....
PLEASE INDICATE PORTION OF FARM WHICH WAS FARMED IN THAT WAY
(E.G. WHOLE, HALF, QUARTER)? ....

6. WHAT PORTION OF YOUR INCOME IS DERIVED FROM FARMING
(E.G. WHOLE,HALF,A QUARTER,LESS THAN A QUARTER)?...............

7. DO YOU PRACTISE A PARTICULAR FORM OF ORGANIC AGRICULTURE
(E.G. BIO- DYNAMIC)?..............................

8. WHAT ARE THE MAIN ACTIVITIES ON YOUR FARM?

	CROP/STOCK	ACRES	NO. OF STOCK;		CROP/STOCK	ACRES	NO. OF STOCK
1.	....	.....	....	5.	....	.....	....
2.	....	.....	....	6.	....	.....	....
3.	....	.....	....	7.	....	.....	....
4.	....	.....	....	8.	....	.....	....

9. WOULD YOU BE WILLING TO PARTICIPATE IN A FOLLOW-UP SURVEY?
....
....
....

APPENDIX 5: DATA COLLECTION

A.5.1. Fertilisers

Fertiliser data were obtained by multiplying the rate per hectare (a figure most farmers knew without hesitation) by the area of the particular crop. Prices of the different fertilisers were generally known by farmers. If there was any doubt about the prices, they were verified by asking local stock agents, or by comparing them with other interviewed farmers (taking into consideration likely differences in transport costs). In some cases total expenditure for fertilisers was calculated on the farm and compared with the farmer's estimate, providing a check for accuracy.

A.5.2. Feed

Farmers were asked for expenditure on feed. The total amount was divided by the dry stock equivalent (number of sheep plus number of goats plus eight times number of cattle), to obtain the expenditure on feed per animal.

A.5.3. Pesticides

Data for pesticide used in crop production (including storage) were obtained in the same way as those for fertilisers. Where farmers were not sure about the rate at which the pesticide was applied (which occurred more frequently than with fertiliser), they were asked for the application per hectare as compared to the recommended rate. Farmers usually knew without hesitation whether they had applied the recommended rate or, for example, twice or half that amount.

A similar method was employed for the collection of data on pesticide use in animal husbandry, where the number of animals treated was multiplied by the dose administered, and by the price of the material.

Where farmers did not know the price, estimates were made with the aid of a publication by the South Australian Department of Agriculture (1986), Gammie and Dellow (undated), and Mallise and May (undated). Average costs per animal treated were the average costs for all treatments, where treatments for beef were divided by eight.

The fs farmers did not use any pesticides which are not allowed in the Australian Organic Standards (NASAA, undated) on crops. Exceptions were some spotspraying of weeds by one farmer (less than 1 percent of total area), the use of seed protectant by another farmer, and pesticides used on stored grain. Although the use of seed protectants means that the crops are unacceptable under the Organic Standards in Australia at present, the farm on which this substance was used was included in this study. This was because the treatment is extremely cheap and, although the farmer considered it to be essential, other sustainable farmers mentioned no problem in connection with non-use. Thus, the application seemed likely to have a minimal effect on both farm cost and farm income.

A.5.4. Fuel

Figures for expenditure on fuel were sometimes difficult to obtain. Generally farmers had records, either on money spent, or quantity supplied to the farm in that particular year. However, one of the problems with collecting data for expenditure on fuel was that the fuel tanks on the farm might not be filled, or the bills paid, at the same time each year. For example, tanks can be full at the beginning of the year, and empty at the end. In cases where fuel expenditure of two neighbours seemed unrealistically different from one another, data were requested about the years preceding and following the survey year. Giving due consideration to differences in weather conditions (and number of cultivations of the fields before planting) between those years, an average expenditure per hectare cropped was arrived at, and imputed.

In two cases the estimate was established in a different way. In the first case, the sustainable farmer (A) gave such a rough estimate that a note was made on the farm that the figure should be checked with a sustainable farmer in the neighbourhood (B) for comparison (no description of the cultivation activities had been obtained, and it was therefore assumed that the cultivation practices were more likely to be similar to B than to the conventional neighbour C). It turned out that A used $97 per hectare cropped, almost twice the maximum of any of the other farms. B and B's conventional counterpart both spent $27 per hectare, while C spent $39 per hectare cropped. In order to be sure not to advantage sustainable farming a cost of (fractionally lower than) $39 per hectare operated was imputed for A (see below).

The second case is a conventional farmer who pooled some of the inputs (including fuel) with a brother farming in the neighbourhood. During the analysis, it became clear that the figures were wrong, while a request for more information was not expected to lead to improved information. It was therefore decided to assume that a similar amount of fuel had been used per hectare cropped to that of the sustainable neighbour ($21). This was done despite the fact that the description of the cultivation methods was such that the conventional farmer certainly would not have used less, and probably more, fuel.

It was likely that the two conventional farmers in both cases had spent more on fuel per hectare cropped than their sustainable counterparts. The imputed expenditure for the sustainable producer in the first case, and the conventional farmer in the second were included as fractionally lower and higher, respectively, than that of their neighbours. This was done because, although it does not influence the average, inclusion in the Wilcoxon and Mann-Whitney test was still guaranteed. With differences of zero between the two farmers of one pair, these pairs would automatically be omitted from these tests.

A.5.5. Credit

Data about the present indebtedness of the farmers was difficult to collect. Although some farmers had no objections to divulging information about their financial affairs, in many cases an explanation about the reasons for its relevance to the survey was essential to obtain the data.

Questions were asked about the total amount borrowed, the main purpose of borrowing, and the source of borrowing. Although most farmers were hesitant to supply the information, the data are considered to be reasonably reliable.

A.5.6. Machinery

Farmers were asked for details about capital items, including a description of the item, year of manufacture, percentage owned, and market values as perceived by the farmer. Although the ABARE uses individual rates of depreciation for each item, in this study depreciation rates for groups of items were used as follows:

Item	Percentage
Motor vehicles:	22.5
Farm equipment:	15.0
Non-portable irrigation:	5.0
Portable irrigation:	5.0
Portable yards:	15.0
Fences:	4.5
Buildings:	3.75

The use of rates for each item individually would undoubtedly lead to a more accurate calculation of the depreciation costs. However, it was decided that the increased accuracy did not warrant the required increased resources. The rates adopted reflect the median of the individual ABARE rates in each group, or of the main items in the group.

Farmers' estimates which appeared unreasonable were changed to reflect average values, taking into account size and year of manufacture.

A.5.7. Labour

The number of weeks worked by permanent and casual labour was recorded, together with the payments to labour, where applicable. In those cases where no payments were made (generally family labour) the Minimum Pastoral Award was used to obtain imputed wages.

A.5.8. Land

Figures in Table A.5.14 reflect the total area operated by all farmers. However, two farms presented special problems with regard to further calculations. The first farm was in an area where environmental conditions (soil type, climate) changed considerably within a short distance. The conventional farmer had extended the farm into the area with poorer quality soil and lower rainfall. This block was approximately three times the size of the original farm. Although 'total area operated' represents the average of the total area of all farms, the comparison of inputs used and outputs obtained per hectare would be rather meaningless if the less productive area was included. For this reason, only data from the original farm are presented for all variables except for 'farm area operated'. This necessarily led to some adjustments to the supplied data. For example, as a similar area was cropped on both parts of the farm, cost of machinery and equipment (items which are associated with cropping, and including depreciation, repairs and maintenance, running costs such as fuel, oil and grease, insurance and plant lease) were halved for the purpose of this study. Only the value and size of the original block was taken to obtain the value of land per hectare. With regard to livestock, the farmer estimated that approximately one eighth of the stock was kept on the home farm. All costs and returns associated with stock were divided by eight, and incorporated. Labour requirements were allocated on the basis of 40 percent of the time allocated for each of the 160 hectares of crop, and 20 per cent for the 2000 sheep. This means that 40 per cent plus one eighth of 20 percent of total labour used was allocated to the included part of the farm. Half of the expenditure on rates and taxes, interest payments and cost of operator house was included.

The circumstances of the other case were somewhat similar, although the second part of the farm was less than half of the original farm.

Problems similar in nature, but of considerably less proportion, occurred on one fs and one ss farm. Areas of these farms were located in two places. Since all records were combined for both parts of the land, it was decided to include the whole farm in the comparison.

Estimates of arable area as a percentage of total area operated, and of area cropped as a percentage of arable area reflect the areas included for input and output calculations.

Estimates for the improved capital value of land were obtained from the farmer, the farmer's counterpart, the local Officer of the Department of Agriculture, and a local real estate agency. Questions were asked about prices of agricultural land in general in the area, about factors which influenced those prices, and about prices of the particular farms. These questions were asked not only to get some idea about relevant factors influencing land prices, but also to obtain an idea about the basis of estimates of the farm value by the different people. Generally, the estimates of the different sources for the two farms were close. In such a case the average would be taken. If one of the four estimates was totally different from the others, it was usually disregarded, unless there was a good reason not to do so.

The improved capital value is the value of the land, and any improvements made to the land. These include structures and buildings, such as fences, dams, machinery and stock sheds, and the operator's house.

Since the survey was carried out in October 1986 and February 1987 the estimates were adjusted to reflect values for July 1985, that is, the opening values for the 1985-86 cropping season. The adjustment was made using figures for nominal changes in land values for the relevant time period, provided by the ABARE (J.Tucker, personal communication, April 1987).

The unimproved capital value was calculated by deducting the estimated values of fences and of the farm buildings and structures (including the operator's house) from the improved capital value. This is correct in areas where the buildings increase land value, although there are areas where buildings do not contribute to the total farm price. However, in this study the unimproved capital value has been calculated in this way for all farms included.

APPENDIX 6: DETAILS ABOUT CALCULATIONS OF FINANCIAL MEASURES

A.6.1. Total Cash Costs

The ABARE defines 'total cash costs' as

'actual payments made by the farm business for hiring casual and permanent labour (excluding family labour), materials, services, payment to sharefarmers, produce purchased for resale, rent, interest and livestock purchases. As far as possible, costs relating to capital development and private expenditure in relation to the farm business are excluded from operating expenses.' (Campbell 1981).

Details about the costs included are as follows:

1. Stock purchases
2. Labour:

wages paid to hired labour, excluding manager, and including shearing and crutching

3. Materials:

agistment
fertilisers
fodder
seed
pesticides
    fuel, oil, grease
        livestock and wool materials
        repair and maintenance:
            unspecified
            buildings
            fences, yards
            motor vehicles, tractors
            other plant
            water supply
            other
        other unspecified materials

4. Services:

administrative services

contracts and plant hire for production activities (such as seeding, spraying, mulesing)

wool handling and marketing charges (for example wool packs)

total insurance premiums

other motor vehicle expenses (incl. 3rd party)

total rates and taxes

veterinary fees

freight: stock and wool

deductions: wool

water charges

5. Rent
6. Interest
7. Plant lease

All cost data were collected on the farm, except those for administrative charges. These were imputed using the ABARE's figures for each State. As administrative costs (for example, accounting, banking, telephone and advisory services) are partly fixed, and partly dependent on the amount of business carried out, costs were calculated for each farm individually. The calculations reflected the fixed and variable nature of this amount in the following way:

$$\{(ABARE/2) + ((ABARE/2)/\text{area operated ABARE}) \times \text{area operated on sample farm}\}$$

where ABARE = ABARE State figures.

A.6.2. Total Cash Receipts

The total cash receipts include the following:

1. Receipts for crops net of handling and marketing charges

For wheat this was the Guaranteed Minimum Price and the (discounted) amount paid at a later stage (Australian Wheat Board 1988).

Estimated receipts for crop stocks were addedwhile pool payments for previous years were not counted.

2. Receipts for stock net of handling and marketing charges
3. Off-farm sharefarming receipts
4. Total gross receipts for wool
5. Receipts for skins and hides
6. Agistment receipts
7. Off-farm contracts
8. Rebates and refunds
9. Plant hire receipts
10. Other farm receipts

A.6.3. Farm Cash Operating Surplus

Total Cash Receipts - Total Cash Costs

A.6.4. Return to capital and management

Farm Cash Operating Surplus
+ buildup in stock (at average State prices, provided by ABARE (J.Tucker, personal communication, April 1986)).
- depreciation of machinery
- operator and family labour.

This measure s expressed in terms of unit of land or capital invested.

A.6.5. Adjusted Return to Capital and Management

Return to Capital and Management
+ interest
+ rent

APPENDIX 7: ESTIMATED CROP YIELDS AS A FUNCTION OF FERTILISER USE

Table A.7.1: Estimated crop yields (tonnes per hectare) under rotation 1 as a function of level of fertiliser (tonne per hectare)

Item	Level of application				
	1	2	3	4	5
Sustainable farmer					
Rock phosphate:	0.12	0.16	0.20	0.24	0.28
Yield:					
Wheat (year 1)	1.92	2.14	2.30	2.40	2.44
Wheat (year 2)	1.72	1.94	2.10	2.20	2.24
Oats	1.39	1.51	1.60	1.65	1.67
Conventional farmer					
Starter 12:	0.03	0.04	0.05	0.06	0.07
Yield:					
Wheat (year 1)	1.92	2.14	2.30	2.40	2.44
Oats	1.39	1.51	1.60	1.65	1.67

Table A.7.2: Estimated crop yields (tonnes per hectare) under rotation 2 as a function of level of fertiliser (tonne per hectare)

Item	Level of application				
	1	2	3	4	5
Sustainable farmer					
Rock phosphate:	0.12	0.16	0.20	0.24	0.28
Yield:					
Wheat (year 1)	1.87	2.09	2.25	2.35	2.39
Oats	1.29	1.41	1.50	1.55	1.57
Conventional farmer					
Starter 12:	0.03	0.04	0.05	0.06	0.07
Yield:					
Wheat (year 1)	1.82	2.04	2.20	2.30	2.34
Oats	1.29	1.41	1.50	1.55	1.57

Table A.7.3: Estimated crop yields (tonnes per hectare) under rotation 3 as a function of level of fertiliser (tonne per hectare)

Item	Level of application				
	1	2	3	4	5
<u>Sustainable farmer</u>					
Rock phosphate:	0.12	0.16	0.20	0.24	0.28
Yield:					
Wheat (year 1)	1.62	1.84	2.00	2.10	2.14
Wheat (year 2)	1.42	1.64	1.80	1.90	1.94
Oats	1.01	1.21	1.30	1.35	1.37
<u>Conventional farmer</u>					
Starter 12:	0.03	0.04	0.05	0.06	0.07
Yield:					
Wheat (year 1)	1.47	1.69	1.85	1.95	1.99
Wheat (year 2)	1.27	1.49	1.65	1.75	1.79
Peas	0.89	1.01	1.10	1.17	1.21
Oats	0.99	1.11	1.20	1.25	1.27

Table A.7.4: Estimated crop yields (tonnes per hectare) under rotation 4 as a function of level of fertiliser (tonne per hectare)

Item	Level of application				
	1	2	3	4	5
Sustainable farmer					
Rock phosphate:	0.12	0.16	0.20	0.24	0.28
Yield:					
Wheat (year 1)	1.67	1.89	2.05	2.15	2.19
Wheat (year 2)	1.52	1.74	1.90	2.00	2.04
Oats	1.01	1.21	1.30	1.35	1.37
Conventional farmer					
Starter 12:	0.03	0.04	0.05	0.06	0.07
Yield:					
Wheat (year 1)	1.57	1.79	1.95	2.05	2.09
Wheat (year 2)	1.37	1.59	1.75	1.85	1.89
Peas	0.99	1.11	1.20	1.27	1.31
Oats	1.09	1.21	1.30	1.35	1.37

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