F I N A L   R E P O R T

Economic Analysis of the Corangamite Soil Health Strategy

Prepared for

Department of Primary Industries

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In association with

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Introduction

The impacts of poor soil management, including: soil acidity, erosion, salinity, acid sulphate soils and soil structural decline (sodicity, waterlogging, compaction) threaten agricultural production and thus jeopardise agricultural industries throughout the Corangamite region.

Various management plans and strategies have been developed for the region that address only part of the soil health story. These include:

Corangamite Regional Nutrient Management Plan
Corangamite Waterway Health Strategy
Corangamite Salinity Strategy
Corangamite Regional Catchment Strategy
Regional Native Vegetation Plan
Regional Rural Drainage Strategy

The overall objective of the Corangamite Soil Health Strategy (CSHS) is to build on existing work and develop an over-arching plan that addresses all soil health issues. This Plan will therefore help to ensure the long-term production and sustainability of land in the region while minimising the negative off-site impacts.

The costs of poor soil health were identified *with* and *without* the Corangamite Soil Health Strategy. This information was used in a benefit-cost analysis of the actions included in each Program. Cost sharing principles, based on the economic principles of beneficiaries' pay and/or polluters pay, were discussed to assist in formulating cost sharing arrangements for each action.

It is understood that there is imperfect scientific knowledge from which to make predictions about the losses in farm production and other forms of damage resulting from the various causes of poor soil health. This means that the results of any economic analysis of soil health must, at best be regarded as indicative. To the extent that this study identified major deficiencies in technical understanding, this will provide useful information about priorities for further research.

The Corangamite Catchment Management Authority (CCMA) region encompasses an area of 1,335,000 hectares, which is around 6 per cent of the total area of Victoria. The major river catchments in the region include the Barwon, Moorabool, Corangamite (including the Woady Yaloak River system) and Otway Coast Basins.

2.1 Current land Use and Enterprise Mix

Land use data within the CCMA region was sourced from the land use data layer used within the Land Use Impact Model (LUIM). For more information refer to the Department of Primary Industries in Bendigo.

Table 2-1: Land Use in the Corangamite Region

Land Use	Area	
	Hectares	**%**
Agriculture	899,893	67%
Production Forest	133,356	10%
Conservation & Natural Environments	117,469	9%
Plantations/Plantation Forest	34,689	3%
Water (incl Lakes Rivers, Wetlands)	47,388	4%
Services (incl. roads)	54,419	4%
Residential	38,583	3%
Other	9,456	1%
Total	1,335,252	100%

Source: Strategic Resource Planning Unit, Department of Primary Industries (2003).

2.2 Agricultural land use

Agricultural land use in the CCMA region is primarily (over 80 per cent) improved pastures for grazing. Table 2-2 shows that the next biggest land use is cropping (mainly cereals).

Table 2-2: Area of agricultural land uses in the Corangamite region

Agricultural Land use (excluding forestry)	Area (Hectares)	Total Area (%)
Grazing Modified Pastures	736,695	82%
Grazing Natural Vegetation	61,796	7%
Cropping	94,676	11%
Horticulture (incl irrigated)	4,952	1%
Irrigated Pastures/Cropping	988	0%
Intensive Agriculture	785	0%
Total	899,893	100%

2.3 Production Systems

Production systems vary in the study area, and the benefits of the proposed action will be different for different production systems. MacEwan (2003) stated that there are five main production systems in the study region, which are relatively specialised geographically with their own set of soil management problems. Partly based on these, the main production systems that have been identified in the CCMA region are:

1. Broad Acre Cropping
2. Dairy
3. Broad Acre Grazing of Cattle and Sheep
4. Farm Forestry
5. Native Public Forestry

Soil degradation involves a set of processes that cause losses in agricultural productivity. Such processes include soil erosion, salinisation of land and streams, soil acidification, and decline of soil structure. It is common that degraded or unhealthy soils will be characterised by the simultaneous occurrence of several of these processes. In other words, some agricultural practices jointly produce several forms of degradation, for example, as the acidity of a soil increases, its structure may decline leading to erosion, increasing nutrient loads in streams, increasing groundwater levels and salinity.

Improving the health of agricultural soils means adopting actions and practices to reduce erosion, reduce salinisation, ameliorate rates of soil acidification, reduce structural decline, and maintain fertility. Just as some practices jointly produce various forms of degradation, it is fortuitous that other practices can jointly produce reductions (benefits) in various forms of degradation. For example, the planting of deep rooted perennials in appropriate locations may simultaneously reduce groundwater recharge, reduce nitrate leaching – the latter being one of the major causes of soil acidification - and reduce erosion.

The Corangamite Soil Health Strategy Technical Group identified thirteen soil health issues in the study area. These are:

- soil acidity;
- acid-sulfate soils;
- soil structure (compaction by animals, cultivation, dispersive soils;
- soil salinity and waterlogging;
- water erosion (gully, tunnel, rill and sheet);
- wind erosion;
- soil nutrient decline;
- excess nutrient inputs;
- landslips;
- contaminants;
- soil biota;
- organic carbon; and
- coastal dune movement.

Where available, information on the occurrence of each of these soil health issues was obtained from the Land Use Impact Model (LUIM).

3.1 Soil Acidity

Soil acidification is an important land degradation issue threatening the productivity of agricultural soils in the CCMA region. Whilst most of the region's soils are naturally acid at the surface, agricultural practices that add more nitrogen to the soil than plants can remove have increased the rate of soil acidification (MacEwan, 2003). Practices that remove large quantities of plant material also contribute to soil acidification.

The impacts of soil acidity include:

- the toxicity and deficiency of elements;
- increased nitrate contamination of ground water and reduced water quality;
- losses in plant productivity (reduced farm yields, farm income);
- reduced vegetative cover, leading to accelerated run-off and erosion;
- declining pH of streams;
- associated problems with soil structure (for example, irreversible clay structural damage); and
- damage to infrastructure.

The likelihood of soil acidification by production system in the CCMA region is shown in Table 3-1

Table 3-1: Land Use (ha) according to likelihood of soil acidification in the CCMA region

Production System	Very Low	Low	Moderate	High	Very High	Total
Cropping	94,038	0	0	0	0	94,038
Farm Forestry	NA					34,179
Grazing	0	0	20,734	482,658	290,948	794,339
Dairy	0	0	0	8,744	162,193	170,937
Production Forestry	NA					133,321
Total	94,038	0	20,734	491,401	453,141	1,226,814

NA = Not assessed

The likelihood of soil acidity affecting production systems in the CCMA region is greatest for grazing production systems. Predictions have been made for increases in the rate of soil acidification throughout the region.

3.2 Soil Erosion

Soil erosion is the detachment of soil particles from the soil surface, their transport and deposition. In Australia, the most common erosion agents are wind and water. Soil erosion is a natural process that has been responsible for the evolution of land surfaces. Of greater concern are the accelerated rates of erosion that are occurring in response to changes in land management. Soil formation is a slow process and soil loss by erosion cannot be replaced in human time frames.

Erosion can be classified as either wind erosion or water erosion. Various forms of water erosion are recognised, sheet and rill erosion, gully erosion, floodplain scour and stream channel erosion are generally the main ones of interest.

The impacts of soil erosion include:

- sedimentation and turbidity of waterways;
- algal blooms in waterbodies and waterways due to nutrients in the sediments;
- loss of productive topsoil (fertility & organic matter);
- gully erosion leads to paddocks becoming inaccessible for vehicles and for moving stock; and
- damage to infrastructure.

The likelihood of sheet and rill erosion affecting soils in the Corangamite region is shown in Table 3-2, the likelihood of wind erosion affecting soils is shown in Table 3-3, and the likelihood of gully and tunnel erosion is shown in Table 3-4.

Table 3-2: Land Use (ha) according to likelihood of sheet and rill erosion in the CCMA region

Production System	Very Low	Low	Moderate	High	Very High	Total
Cropping	0	2,832	9,924	76,820	4,463	94,038
Farm Forestry	31,384	2,795	0	0	0	34,179
Grazing	0	218,307	458,948	96,789	20,295	794,339
Dairy	NA					170,937
Production Forestry	0	71	13,176	12,494	107,579	133,321
Total	31,384	224,005	482,049	186,103	132,337	1,226,814

NA = Not assessed

Table 3-3: Land Use (ha) according to likelihood of wind erosion in the CCMA region

Production System	Very Low	Low	Moderate	High	Very High	Total
Cropping	0	0	172	79,583	14,283	94,038
Farm Forestry	34,179	0	0	0	0	34,179
Grazing	0	45,155	519,608	174,203	55,374	794,339
Dairy	170,937	0	0	0	0	170,937
Production Forestry	NA					133,321
Total	205,116	45,155	519,780	253,786	69,656	1,226,814

NA = Not assessed

Table 3-4: Land Use (ha) according to likelihood of gully and tunnel erosion in the CCMA region

Production System	Very Low	Low	Moderate	High	Very High	Total
Cropping	NA					94,038
Farm Forestry	34,179	0	0	0	0	34,179
Grazing	0	0	171,174	285,282	337,884	794,339
Dairy	0	17,352	76,682	64,595	12,308	170,937
Production Forestry	133,321	0	0	0	0	133,321
Total	167,500	17,352	247,856	349,877	350,191	1,226,814

NA = Not assessed

3.3 Acid Sulfate Soils

Potential acid sulfate soils (ASS) are generally waterlogged and rich in iron disulfide. Activities such as cropping, grazing, urban development, flood mitigation drains, dredging, sandmining and highway construction can lead to these soils being exposed to air causing them to oxidise and become actual acid sulfate soils. During this process, the iron sulfides oxidise which produces sulfuric acid. The soil can neutralise some of the sulfuric acid, but “the remaining acid moves through the soil, acidifying soil water, groundwater and surface water” (Sammut, 2000).

Acid sulfate soils can have an effect on soils, water and can damage the environment. The impact of ASS include:

- reduced pH in soils and surface water;
- reduced farm productivity, both plant and animal productivity;
- damage to infrastructure (bridges, pipes, drains, roads, buildings);
- kill fish and oysters or make them more vulnerable to disease; and
- infestations of acid-tolerant weeds and waterplants.

No information was available on the distribution of potential acid sulfate soils in the CCMA region.

In the Corangamite CMA region, there is some 9,614 hectares of potential ASS on private land and 4,231 hectares on public land (DPI, 2003). Most of the potential ASS is found along the coastal fringes of the region. Undisturbed, potential ASS cause little or no problems. However, if allowed to oxidise (when potential ASS is exposed to air due to removal of topsoil or water) acid sulfate soils can begin to release sulfuric acid that impacts on agricultural production, infrastructure and the environment. Urban and regional development is often the main cause of disturbance of potential ASS.

3.4 Soil Structure

Soil structure can be defined as the way the building blocks of soil (sand, silt, clay and organic matter) are arranged and the size of pores between them. The building blocks come together to form aggregates, which are joined by fungal hyphae and plant roots to form larger stable aggregates. The pores are important for transporting and storing water, carrying air and facilitating root growth.

Soil structural decline was defined by Moran (1998) as the loss and/or rearrangement of soil pore spaces, which:

- renders the soil less effective for infiltration, transport and storage of water, and diffusion of gases; and
- results in a soil environment less conducive to biological activity.

The impacts of poor soil structure include:

- yield decline, due to reduced seedling emergence, decreased root exploration, reduced vigour and reduced water availability;
- reduced quantity and variety of soil biota;
- compaction of topsoil;
- soil erosion;
- reduced water infiltration, increasing waterlogging and pugging; and
- pollution of waterways from nutrients and other chemicals as a result of increased surface flows.

The likelihood of soil structural decline impacting on production systems in the CCMA region is shown in Table 3-5.

Table 3-5: Land Use (ha) according to likelihood of soil structural decline in the CCMA region

Production System	Very Low	Low	Moderate	High	Very High	Total
Cropping	39,491	26,074	20,233	8,240	0	94,038
Farm Forestry	34,179	0	0	0	0	34,179
Grazing	0	249,890	135,370	328,484	80,595	794,339
Dairy	0	6,775	17,313	17,473	129,376	170,937
Production Forestry	0	1,186	57,449	28,698	45,989	133,321
Total	73,670	283,926	230,365	382,893	255,960	1,226,814

NA = Not assessed

The likelihood of soil structural decline affecting soils in the CCMA region is greatest for dairying. Grazing farms are also likely to be affected.

3.5 Soil Salinity and Waterlogging

Salinity can be classified as either natural or human-induced. Natural or primary salinisation occurs over the longer term and results from natural processes, which accumulate salt in an area. Human-induced or secondary salinisation is the result of human-induced processes such as land clearing or irrigation whereby salt stored in the soil profile or groundwater is mobilised. The more recent spread in soil salinity in both irrigated and dryland catchments is in response to secondary processes.

The increase in salt levels in the soil came about through changes in land-use over the last 200 years. Tree clearing and common agricultural practices, such as fallowing, have caused groundwater levels to rise. The rising groundwater has mobilised salt stored in soil and rock, and distributed it to rivers and topsoil, where it can cause damage. This is particularly the case where watertables rise to within two metres of the ground surface, and discharge occurs.

In an agricultural context, waterlogging is saturation of the root zone for long enough to be detrimental to plant growth. Soil salinity is the result of salt accumulation in the soil to the extent of reducing the capacity of the soil to support plant growth.

The impacts of soil salinity and waterlogging include:

- losses in yield;
- decline in soil structure;
- waterlogging;
- increased wind and water erosion from bare ground;
- water quality impacts (salinity and nutrients); and
- corrosion of infrastructure.

Raised bed technology was developed in the Corangamite region and has been readily adopted throughout the catchment to ameliorate waterlogged soils and increase dryland-cropping yields.

4.1 Introduction

Some *agricultural practices* can jointly and simultaneously produce improvements in a number of dimensions of soil health. This evaluation is directed at determining the costs and benefits of implementing the CSHS (both on and off farm) that would stem from enhanced adoption of such agricultural practices as encouraged by the actions set out in the strategy. These benefits can be added to obtain the overall benefit of the strategy.

The production systems targeted by these actions are outlined in Section 2.3.

4.2 Corangamite Soil Health Strategy Programs

The action programs included within the CSHS include:

1. Support Action Program;
2. Education and Extension;
3. Research, investigation and filling knowledge gaps;
4. Broadacre Grazing;
5. Cropping;
6. Dairy;
7. Productive and Farm Forestry;
8. Local Government/Government agencies; and
9. Review and Upgrade Program.

Within this benefit cost analysis of the CSHS we have focussed on the quantification of management actions associated with farm best management practices. For each of the other programs, the actions are largely about education and extension to achieve the adoption of best management practices. We have quantified the costs for these programs to implementation the CSHS in Section 8.2.

4.3 Issues Relating To The Implementation Of CSHS

The CSHS aims to alter agricultural practice so as to reduce soil degradation and the accompanying economic losses. The aggregate economic effects on society would be improved if the total benefits from reduced soil degradation, that is, the sum of the benefits to farmers and benefits to other members of the community stemming from avoiding off-site damages, exceeded the costs of actions to reduce soil degradation.

Achievement of such an improvement in economic welfare, however, requires that all parties are fully informed about the relevant causes and effects of soil degradation. This is not usually the case when off-site effects are involved because there are no direct signals that transmit information to farmers about the damage they cause in other places. Therefore, farmers do not account for the cost of these damages in their decision making. Conversely, they do not account for the off-site benefits from practices that reduce soil degradation.

In these circumstances, a damaging agricultural practice may be profitable to farmers but not to society, while improved practices may be profitable for society but not for farmers. This may create a case for government involvement either to impose a cost on farmers (a 'pollution' charge) or to contribute in some way on behalf of the off-site beneficiaries of reduced damage to help farmers ameliorate the causes of soil degradation. Actions of this nature, in the form of incentives such as cost-sharing arrangements for some practices are envisaged as part of the CSHS.

A closely related situation is where the new practice is not 'sufficiently' profitable for farmers to embrace it. This situation may also create a case for government intervention in the form of an incentive that attempts to overcome the 'threshold' of profitability.

At the opposite end of a continuum is the situation where a change in farming practice to reduce soil degradation, say soil acidity, is sufficiently profitable to farmers for them to adopt it without government intervention. By reducing the on-site damages in a way that was sufficiently profitable to them, farmers would also reduce the damages that acid soils were causing to others. In this situation there would be no need for government intervention to improve the welfare of society.

In other circumstances, however, it may be feasible and less costly to increase farmers' awareness of the off-site effects of their actions and attempt to persuade them to change their behaviour, say, through community education or extension programs. Where a long-term view needs to be taken, education of the next generation of landholders while still at school might also be appropriate. This form of action is a major feature of CSHS through the community education program, which aims to increase community awareness and understanding of the impact of soil health on catchment health and of the processes of soil degradation and remedial actions.

Another case in which community education and extension would be important is where farmers' knowledge about the profitability of an improved practice or confidence in its use and effects may be deficient. Here the extension program would aim to inform farmers about profitability and/or to increase their confidence and skills.

Given that the problem of soil degradation could be tackled by different means, it is appropriate to examine some of the many factors that might influence farmers' decisions to adopt a change that would reduce soil degradation.

4.4 Adoption of practices to reduce soil degradation

The adoption of land management practices that are designed to reduce soil degradation is a key issue influencing the achievement of the potential benefits of the CSHS. Unfortunately, there is no formula for predicting the rate and ultimate level of adoption of any new agricultural practice. Instead, we must rely on the best guess estimates of experts to make such predictions, however, for obvious reasons, these estimates will be surrounded by considerable uncertainty.

The adoption by farmers of soil conservation actions appears to be influenced by a number of general matters related both to the action itself and to the landholder. These include:

- recognition that an environmental problem exists;
- a perception that the problem could be rectified by a technically feasible change in farming practices;
- the farmer's perception of the profitability of the change in practice (that is, net returns greater than for current farm practices); and
- the presence of psychological motivations to act (these may be related to concerns for the environment as well as profit) (Sinden and King 1990, Cary and Wilkinson 1997).

Some of the more detailed factors embodied in the above might be:

- time to achieve benefits and the farmer's rate of time preference for income;
- the farmer's skills in relation to the new practice;
- the degree to which the change permits the achievement of landholders' non-profit, non-environmental goals;
- compatibility with cultural values and beliefs;
- the complexity of the change;
- uncertainty about future outcomes in an unfamiliar form of production;
- the landholder's aversion or otherwise to uncertainty;
- the availability of funds and the cash flows produced; and
- the opportunity to conduct trials or observe potential outcomes.

It is not the purpose of this evaluation of the CSHS to consider all aspects of the adoption process in detail. Rather, we focus on some aspects that might be influenced by incentive mechanisms, and by community education and extension programs.

4.4.1 Incentive mechanisms

As discussed above, when the total economic benefits (both priced and unpriced) of reducing soil degradation are greater than the costs of reducing degradation, government intervention is not required. However, government may consider the provision of economic incentives in situations where the private benefits of measures to ameliorate degradation are less than the private costs but the total benefits (private plus public) exceed the on-farm (private) costs. This condition is taken to include situations where farmers' profits are less than the 'sufficient' level of profit at which adoption levels acceptable to government would occur.

Clearly, the costs of any incentive mechanisms that might be used should not cause the total social costs of an action to exceed the total social benefits. In this respect, care must be exercised to guard against the use of subsidies that lower the private costs of correcting soil degradation so that more degrading methods of farming become profitable.

4.4.2 Community education and extension

Several previous studies of adoption of conservation practices have shown the importance of a number of variables in farmers' adoption decisions that can be influenced by education and extension. To the extent that the findings of those studies can be extrapolated to soil degradation issues in the CCMA region of Victoria, they confirm that it is appropriate for CSHS to attempt to influence:

- landholders' perceptions about the profitability of changes in farming practice;
- landholders' recognition of an environmental problem; and
- the environmental orientation of landholders.

It is also clear from one of these studies that the effort expended on extension has an important role to play bringing about change in farmers' behaviour toward conservation practices. A significant proportion of the CSHS budget is devoted to extension effort.

5.1 Benefit Cost Analysis

Benefit cost analysis has been used in evaluating the proposed actions of the Corangamite Soil Health Strategy. This methodology is applied by:

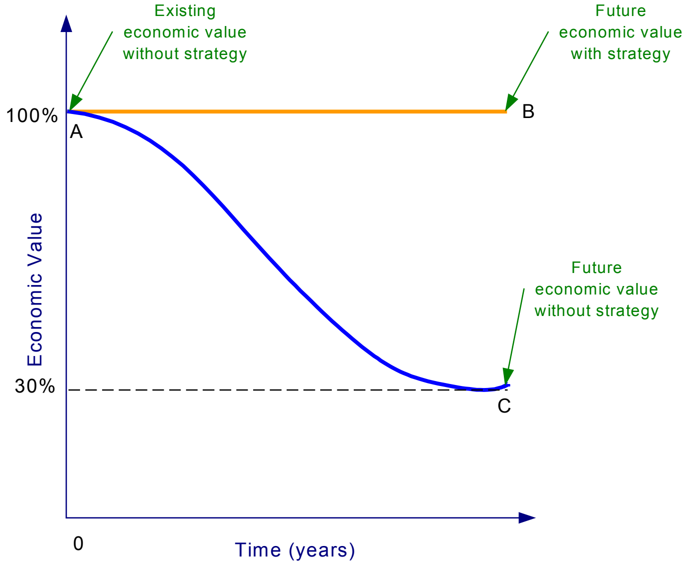
- estimating the impacts of soil degradation *without* the Corangamite Soil Health Strategy;
- estimating the impacts of soil degradation *with* the Corangamite Soil Health Strategy;
- subtracting the *without* estimates from the *with* estimates to obtain the benefits of the Corangamite Soil Health Strategy; and
- comparing the benefits and costs.

The process of discounting enables the direct comparison of amounts of money that accrue in different time periods. Discounting gives greater weight to initial benefits and costs and less weight to those in the distant future. The present value of a future sum is lower the higher the discount rate. A 'real' discount rate (based in inflation-free interest rates) of 8 per cent has been used in this evaluation. For more information on discounting, refer to Appendix A.

5.2 With and Without Strategy Scenarios

The benefits of any strategy are measured as the difference in benefits with and without the intended strategy (Figure 5-1). This diagram shows the 'with strategy' scenario as a constant line, suggesting a preservation strategy, while the 'without strategy' scenario shows the future decline in economic value without the proposed strategy. The area ABC in Figure 5-1 shows the benefits of this strategy.

Figure 5-1: With and without strategy scenarios



The unifying principle is that the 'with' and 'without' scenarios must be adequately defined and described because the difference between these two scenarios gives the magnitude of the respective benefits.

5.3 Classes Of Benefits

All the benefits that might arise from a soil health action must be listed in the analysis and valued where possible. For various reasons, it may be useful to classify the benefits in different ways. In this analysis, we make use of three broad classifications of the social benefits that might arise from a soil health program, namely:

- use and non-use benefits;
- priced and unpriced benefits; and
- private and public benefits.

5.3.1 Use and non-use benefits

The use benefits of a soil health action program are those that stem from improvements in the productive use of the soil. Use values will constitute the most obvious benefits because the majority of the soil affected by the action program is used in agriculture. There would also be important off-site benefits from improved soil health that result from improved water quality due to reduced erosion. Improved water quality would reduce the frequency of algal blooms and make the waterways more attractive for recreational use.

Use values can be distinguished from those values, which people associate with such things as the landscape, or waterways and water bodies even though they do not make use of them. These non-use values are more controversial than use values and are associated, amongst other things, with the value people might derive from knowing that improved habitat for native fish or wildlife exists because of improvements in water quality.

5.3.2 Priced and unpriced benefits

We can distinguish between those goods and services provided by actions of a soil health strategy that are traded in markets and those which are not. The former are called priced, or market values, while the latter are referred to as unpriced, or non-market values.

The goods and services produced from agricultural use of the soil are traded in markets and, therefore, can be readily priced. But, of course, not all use values are priced. For example, there is no market for enhanced recreational opportunities that arise from improved water quality. Non-use values do not have prices.

5.3.3 Private and public benefits

The total benefits of the CSHS include both private goods and public goods. Private goods and public goods are terms used in discussions about the extent of excludability of a particular good. By excludability, we mean the ability for users of a good to deny access to other potential users. A major difficulty arises since there are degrees of excludability so, in discussing these matters; economists have described carefully the two extremes to the possible variation in extent of excludability. The terms ‘private goods’ and ‘public goods’ are used to represent those two extremes:

The use of a pure private good is totally excludable; that is, the person possessing the good can deny access to all other potential users. A car is a pure private good - you cannot legally drive my car without my permission.

By contrast, a pure public good is totally non-excludable; that is, once a unit is produced it is available to all. For example, citizens cannot be excluded from the benefits of a program of national defence.

Public and private goods can also be categorised by another characteristic termed the ‘rivalness’ characteristic. Again, pure public and pure private goods represent the extremes of this characteristic.

A pure private good is rival in consumption, that is, your satisfaction is diminished by my consumption. The hamburger I eat cannot be enjoyed by anyone else.

By contrast, a pure public good is totally non-rival in consumption, that is, it can be made available to many users simultaneously without diminishing the satisfaction gained by any one user. The two of us can enjoy a TV transmission simultaneously and your enjoyment does not diminish mine.

Public and private goods seldom exist in the pure forms and many goods possess these two characteristics to varying degrees. This means that there are relatively few examples of pure private goods and public goods and instead the use of most goods has a degree of excludability, and there exists a continuum between pure private goods and pure public goods.

The distinction between private goods and public goods provides the economic characteristics of a good that are relevant in consideration of whether Government needs to be involved in the provision of a particular good and, if so, whether the Government or users should pay for the provision of that good.

6.1 Estimating the on-farm benefits and costs of the CSHS

Private (on-farm) benefits and costs of the appropriate soil health strategy actions are estimated for each of the major production systems in the Corangamite region. In doing so, it was assumed, where costs for additional farm capital are not costed, that the existing farm assets are adequate for implementation of the various actions. The change in operating costs resulting from the actions have been included in the analysis, but not any expenditure on business assets such as extra livestock. The impact on farm cash flow from funding the additional variable costs and extra livestock capital can be considerable, even though it will be generally offset by extra income.

For a list of the key assumptions used in the benefit cost analysis, see Appendix D.

6.1.1 Combination of Farm Practices

In reality, farmers adopt a mix of practices. To account for this we have estimated the cost and benefits of adopting a combination of the identified practices for each production system. This has been based on the average cost and benefit per hectare for each production system.

Where the action is to investigate a practice and the on-farm benefits and costs are uncertain, the practice has not been assessed. More specifically, this applies to the following CSHS Actions:

- Investigate alternative practices for stubble management to encourage stubble retention for cropping;
- Support research into no-till practices for cropping; and
- Further investigate and extend management strategies to reduce nutrient loss to waterways from dairy farms.

6.2 Cropping Production Systems

The CSHS farm practices relevant to on-farm private costs and benefits for cropping are:

- Promote adoption of Bed Farming (raised beds or controlled traffic flat beds as appropriate) to reduce soil compaction and improve soil structure (Action 5.1);
- Encourage appropriate lime and fertiliser application regimes to improve soil fertility and production, and reduce nutrient loss from paddocks (Action 5.2); and
- Promote the adoption of minimal tillage and no-till practices (Action 5.4).

6.2.1 Private Costs

Promote adoption of Bed Farming (raised beds or controlled traffic flat beds as appropriate) to reduce soil compaction and improve soil structure.

The capital cost of converting machinery for use in raised bed cropping has been estimated by the CSHS cropping group as $30,000 per business enterprise. This has been converted to $120/ha by assuming an average property size of 250 hectares.

The development of raised beds for cropping incurs a cost of approximately $200/ha (approximately equal for contractors or on-farm labour).

The annual cost at 8 per cent interest with a 7-year replacement of machinery is $63.60/ha.

Encourage appropriate lime and fertiliser application regimes to improve soil fertility and production, and reduce nutrient loss from paddocks

Estimates from previous RMCG soil health investigations indicate the following:

- Liming costs based on continuous cropping of wheat and canola are approximately $18/ha (0.25t/ha/year at $73/t)
- The cost of manure spreading to improve soil organic matter and fertility is approximately $8/ha (0.2t/ha/year at $40/t)

Good management of soil fertility and soil health may result in a decrease or increase in fertiliser use depending on existing conditions and practices. It is assumed that overall across the production system fertiliser costs will remain neutral as a result of from improving soil fertility.

Total annual costs for liming and increasing soil fertility are $26/ha.

Promote the adoption of minimal tillage and no-till practices

The CSHS cropping group indicated that specialised machinery costs of approximately $20/ha/year are equal to the savings in labour, machinery and fuel costs that result from minimum tillage.

This relates well to previous investigations by Rendell et al. (1996) that found in the Wimmera and Mallee savings in fuel costs ($20/ha/year) were offset by increases in chemical pesticide use ($20/ha/year).

Therefore total additional costs for minimum tillage are assumed to be zero.

6.2.2 Total Private Cost

The combined adopted cost for CSHS farm practices for cropping is presented in Table 6-1.

Table 6-1: Total Private Costs for Cropping

Action	Annual Capital Cost	Additional Annual Operating Cost	Total Additional Annual costs
	$/ha/yr	$/ha/yr	$/ha/yr
Bed farming	63.6	0	63.6
Lime & fertility	0.0	26	26.0
Minimum till	19.9	-20	-0.1
Adopted combined improved practice			**$29.8/ha/yr**

6.2.3 Private Benefits

Promote adoption of Bed Farming (raised beds or controlled traffic flat beds as appropriate) to reduce soil compaction and improve soil structure

According to CSHS working group members, raised beds in waterlogging prone areas can provide 100 per cent yield increases and controlled traffic cropping in dryer areas can increase yields by 10 per cent per year.

We have adopted a 10 per cent increase in income per year based on previous experience.

Encourage appropriate lime and fertiliser application regimes to improve soil fertility and production, and reduce nutrient loss from paddocks

The cropping working group indicated that increasing soil fertility and reducing soil pH can result in higher yields. It was also suggested that the produce may be of higher quality and command a higher price, although it was noted that the opposite could also occur.

We have adopted a 5 per cent increase in yield from liming and soil fertility increases.

Promote the adoption of minimal tillage and no-till practices

The CSHS working group has suggested that minimum tillage can result in yield increases of up to 10-20 per cent. Whilst this is possible for early adopters in ideal situations it is likely the average benefit will be significantly lower than this. For example the FAST report by Rendell et al. (1996) found no significant differences in yield resulting from minimum tillage.

Therefore we have revised this down to 3 per cent based on previous experience.

6.2.4 Combined Private Benefits

The benefits of the strategy action cannot simply be summed, as the full benefit of each action may not be realised if other actions have been/are adopted.

Therefore this study has averaged the benefits for each action and adopted this average as a likely combined benefit. The benefits and combined adopted cost are present in Table 6-2.

Table 6-2: Combined Benefits

Farm Practise	Current gross income	Production increase	Increase in gross income
	$/ha/yr	%	$/ha/yr
Bed farming	900	10%	90
Lime & fertility	900	5%	45
Minimum till	900	3%	27
Combined benefits			**$54/ha year**

6.2.5 Private Cost-Benefits of combined CSHS Farm Practices

The annual net private benefit of CSHS farm practices for cropping is shown in Table 6-3.

Table 6-3: Annualised Cost and Benefit of CSHS farm practices for cropping

	$/ha
Combined Private cost	$29.8
Combined Private benefit	$54
Net Private Benefit	$24.2

6.2.6 Adoption rates

Adoption rates have been estimated from CSHS working group estimates combined with RMCG experience. Resulting estimates were then checked against likelihood tables produced from the DPI Land Use Impact Model (LUIM).

This checking involved comparison of the spatial distribution of the likelihood of soil degradation processes (equivalent to the soil issues presented in Section 3) that each practice addressed to the area that practices would be adopted given assumed adoption rates. Adoption rates were adjusted if a significant discrepancy was found.

Long term trends in ABS data were used to determine the future total area for cropping.

Assumed adoption rates for the no intervention scenario are presented in Table 6-4. The no intervention scenario is what we would expect to occur without CSHS. It is the baseline to compare CSHS actions against.

Table 6-4: Land Areas of Farm Practices Given No Intervention

Farm Practice	Current adoption. (% of cropping Area)	% Increase Each Year Given No Intervention	Area (ha)			
			2003	2013	2023	2033
Total area		1%	94,038	103,876	114,744	126,749
Bed farming	16%	5%	15,314	24,945	40,633	66,186
Lime & fertility	50%	2%	47,019	57,316	69,868	85,168
Minimum till	60%	1%	56,423	62,326	68,847	76,049
Combined	**42.1%**	**2.67%**	**39,585**	**51,502**	**67,007**	**87,180**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and ideally would require surveying for verification.

Assumed adoption rates for the CSHS farm practices are presented in Table 6-5.

Table 6-5: Land Areas of Farm Practices Given CSHS Implementation

Farm Practice	Strategy adoption Rates (% per yr)	Area (ha)			
		2003	2013	2023	2033
Total area	4%	94,038	139,199	206,049	305,003
Bed farming	9.7%	15,314	38,650	97,549	246,200
Lime & fertility	5.6%	47,019	81,080	139,814	241,097
Minimum till	5.5%	56,423	96,378	164,628	281,208
Combined	**6.9%**	**39,585**	**77,386**	**151,285**	**295,751**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and depend upon the level of extension, economic conditions and effectiveness of CSHS.

The above adoption rates result in significant increases in the area where each practice is undertaken. The largest increase is in the area of bed farming which reflects the estimates of the cropping working group of 80 per cent of all cropping being in beds within thirty years. In reality, this adoption rate may be artificially high (refer to Appendix C for discussion).

6.2.7 Total Private Benefit of CSHS Farm Practices

The total private net benefits of the soil health actions are presented below. These amounts have been calculated by multiplying the per hectare costs and benefits by the area of the relevant production system (hectares). This results in a total dollar figure for the costs, benefits and net benefits to be expected for the combined on-farm practices of the strategy.

The baseline no intervention scenario is compared with the predicted amounts calculated for the implementation of the CSHS. This produces the expected costs and benefits that can be attributed solely to the implementation of the CSHS.

Table 6-6 presents the cost and benefit amounts for the no intervention scenario.

Table 6-6: Benefits of no intervention for cropping

	2003	2013	2023	2033
Total Cost	$ 1,181,141	$ 1,536,725	$ 1,999,360	$ 2,601,271
Total Benefit	$ 2,137,604	$ 2,781,134	$ 3,618,400	$ 4,707,726
Net Benefit	**$ 956,464**	**$ 1,244,409**	**$ 1,619,040**	**$ 2,106,456**

Table 6-7 presents the cost and benefit amounts for the strategy being implemented.

Table 6-7: Benefits of CSHS farm practices for cropping

	2003	2013	2023	2033
Total Cost	$ 1,181,141	$ 2,309,047	$ 4,514,023	$ 8,824,596
Total Benefit	$ 2,137,604	$ 4,178,865	$ 8,169,386	$ 15,970,572
Net Benefit	**$ 956,464**	**$ 1,869,819**	**$ 3,655,363**	**$ 7,145,977**

Table 6-8 presents the net cost and benefit amounts for the CSHS for cropping.

Table 6-8: Net Benefit of CSHS farm practices for cropping

	2003	2013	2023	2033
Total Cost	$ -	$ 772,321	$ 2,514,663	$ 6,223,325
Total Benefit	$ -	$ 1,397,731	$ 4,550,986	$ 11,262,846
Net Benefit	**$ -**	**$ 625,410**	**$ 2,036,323**	**$ 5,039,521**

A significant on-farm net benefit of over $5 million by year 30 may be expected through the implementation of the CSHS.

Table 6-9 shows the net present value of implementing the CSHS for cropping at an 8 per cent discount rate over 30 years. This is the difference between the present value of net benefits *with* and *without* the CSHS.

Table 6-9: Net Present Value of CSHS on Cropping

	Present Value @ 8% discount over 30 years ($'000)
With CSHS	$24,688
Without CSHS	$14,379
Net Present Value	$10,309

6.3 Dairy Production Systems

The relevant CSHS actions, and associated farm practices are:

- Encourage optimum chemical composition of dairy soils, including optimum fertiliser rates to avoid excess nutrients and liming acidic soils (Action 6.1);
  - Application of appropriate rates of fertiliser; and
  - Liming.
- Reduce adverse soil health impact of dairy farming on wet or waterlogged soils through improved management practices to reduce environmental impacts (Action 6.2);
  - Grazing management waterlogged soils; and
  - Timing and use of farm machinery.
- Promote and implement best management practices to reduce nutrient and sediment export to waterways (Action 6.3);
  - Reduce nutrient loss to waterways from dairy farms; and
  - Reduce sediment loss from dairy farming systems.

6.3.1 Private Costs

Encourage optimum chemical composition of dairy soils, including optimum fertiliser rates to avoid excess nutrients and liming acidic soils

Application of appropriate rates of fertiliser

Operating costs arise from testing of soil nutrient levels, which facilitates efficient nutrient application and management. According to the CSHS dairy group and RMCG client records these costs are approximately $600/property/year or $3/ha/year assuming an average property size of 200ha.

Liming

The liming of soils occurs at 2-5t/ha every seven years at the reestablishment of perennial pastures at an annualised capital cost of $39.8/ha. Liming also occurs over a quarter of pastures each year at a rate of 1t/ha at an annual operating cost of $15/ha.

This results in an annual cost of $54.8/ha assuming a cost of $50/t for lime based on RMCG records and CSHS dairy group estimates.

Reduce adverse soil health impact of dairy farming on wet or waterlogged soils through improved management practices to reduce environmental impacts

Grazing management waterlogged soils

The actions that have been identified to manage water logged soils and their associated costs are presented in Table 6-10.

Table 6-10: Strategies and costs to reduce waterlogging on dairy farms

Action	Capital Costs per hectare across whole of production system ($)	Annual Capital Costs ($) assuming 8% interest	Additional Operating Cost per hectare ($/ha/yr)	Total Additional Costs ($/ha/yr)
Installation of surface drainage	100	14		
Installation of sub-surface drainage	833 ($2500/ha over 33% of production system)	90		
Improved grazing management.			5	
Installation of feed pads	100	11		
Adopted combined cost	**$1,033**	**$114.7**	**$5**	**$119.7**

Note: Annual costs for drainage infrastructure assume an average 18 year replacement period.

Capital costs have been determined from working group estimates and RMCG experience. Operating costs have been calculated from the CSHS dairy group's estimates of additional labour requirements.

Timing and use of farm machinery

The primary strategies employed to reduce the impact of machinery on soils are:

- Timing of operations to avoid significant soil impacts; and
- Utilising smaller machinery and/or larger low pressure tyres.

Additional capital costs are assumed to be low and have been estimated by RMCG at $25/ha requiring replacement every seven years. This results in an annual cost of $5/ha/year.

Additional operating costs are difficult to quantify as they result from a number of factors. These are :

- A decreased flexibility in the timing of cropping activities;
- Crop yield reductions from less timely applications of fertilisers;
- Reduction of summer pasture yields due to later sowing times (resulting from restricted cultivation of wet soils); and
- Increased costs for cultivation (smaller rig / higher labour).

These operating costs are assumed to be negligible.

Promote and implement best management practices to reduce nutrient and sediment export to waterways

Reduce nutrient loss to waterways from dairy farms

An on-farm action that has been identified by the dairy working group to reduce nutrient run-off is the installation of irrigation infrastructure for effluent reuse.

An effluent reuse system would typically incorporate the application of effluent to land. It is assumed that there is some existing effluent reuse infrastructure on most properties and that this action only requires additional piping and pumping infrastructure. This enables the effluent to be applied to a large area so that soil nutrient concentrations do not reach excessive levels and cause nutrient run-off.

Costs for an effluent reuse system have been determined through consultation with the CSHS dairy group and RMCG experience and records. Capital costs for the additional piping and pumps are $150/ha. Replacement will be required on an average of twelve years resulting in an annualised cost of $20.7/ha/year.

Reduce sediment loss from dairy farming systems

Reductions of sediment loss on dairy farms are achieved thorough establishing buffer strips along riparian zones. Fencing, revegetation and water trough costs have been estimated by the CSHS dairy group at approximately $7/m.

The cost per hectare is dependent upon the number and density of streams (which is unknown). We have assumed that for each hectare of land adjoining a waterway, 100m of buffer strip will be required (ie. one boundary). Buffer strips, therefore, cost $700/ha for all hectares adjoining waterways. Assuming waterways only adjoin approximately 10 per cent of the area, the unit on-farm cost of buffer strips is $70/ha (ie. 10 metres at $7/m).

Buffer strips require replacing approximately every fifteen years resulting in an annual cost for buffer strips of $8.80/ha/year.

6.3.2 Total Private Cost

The sum of the costs for the individual actions amounts to approximately $175/ha/year. The sum of the costs is unlikely to be an effective measure of total costs due to inherent efficiencies in undertaking actions concurrently.

Also, in practice it is likely that land managers will implement the actions in stages or only adopt some of the actions.

Therefore this study has averaged the costs for each action and adopted this average as a likely combined cost of actions for land managers. The costs and combined adopted cost are presented in Table 6-11.

Table 6-11: Total Private Costs for Dairy

Action	Annual Capital Cost	Additional Annual Operating Cost	Total Additional annual costs
	$/ha/yr	$/ha/yr	$/ha/yr
Drainage & grazing management	114.7	5	119.7
Fertiliser management	0	3	3
Effluent reuse	20.7	0	20.7
Reduce machinery compaction	5.0	0	5.0
Reduce sediment loss	8.8	0	8.8
Liming	39.8	15	54.8
Adopted combined improved practice			**$35.3/ha/yr**

6.3.3 Private Benefits

Encourage optimum chemical composition of dairy soils, including optimum fertiliser rates to avoid excess nutrients and liming acidic soils

Application of appropriate rates of fertiliser

Substantial improvements in yields can provide for some on-farm economic benefits, although the majority of benefits will be experienced off-farm through improvements in water quality.

Additionally, there could be significant cost reductions for those users who are applying excess nutrients currently.

A production increase of 0.5 per cent from efficient nutrient management has been adopted for this study.

Liming

The CSHS dairy working group has estimated a 5 per cent increase in production for this action. This is supported by RMCG client records.

Reduce adverse soil health impact of dairy farming on wet or waterlogged soils through improved management practices to reduce environmental impacts

Grazing management waterlogged soils

The practices that have been identified to manage water logged soils are installing surface and subsurface drainage as well as improving grazing management.

Consultation with the CSHS dairy group and RMCG experience has led to the adoption of an overall increase in production of 10 per cent resulting from these practices.

Timing and use of farm machinery

The major benefit of this action is an increase in long-term productivity and pasture growth. This has not been quantified and has been assumed to contribute a benefit of 2 per cent gross margin increase.

Promote and implement best management practices to reduce nutrient and sediment export to waterways

Reduce nutrient loss to waterways from dairy farms

Kane (2003) has estimated that effluent reuse can yield up to $4000/ML through extra pasture yields. Dairy farms in south western Victoria produce on average 3ML/year of effluent, resulting in a possible benefit of up to $12,000/year.

An average benefit of $2,100/ML or $31.5/ha (assuming an average farm size of 200 hectares) has been adopted as the benefit of effluent application to land. This is equal to a 3 per cent increase in total income.

Reduce sediment loss from dairy farming systems

The on-farm benefits of reducing sediment loss are restricted to minimising production decreases resulting from nutrient and soil loss. These benefits are difficult to quantify and have been assumed to contribute a benefit of 2 per cent gross margin increase.

6.3.4 Combined Private Benefits

The benefits of the strategy action cannot simply be summed as the full benefit of each action may not be realised if other actions have been/are adopted.

Therefore this study has averaged the benefits for each action and adopted this average as a likely combined benefit. The benefits and combined adopted cost are present in Table 6-12.

Table 6-12: Combined Benefits of CSHS for Dairy Farms

Farm Practice	Current Income	Production Increase	Increase in Income
	$/ha/yr	**%**	**$/ha/yr**
Drainage & grazing management	1200	10%	120
Fertiliser management	1200	0.5%	6
Effluent reuse	1200	3%	36.0
Reduce machinery compaction	1200	2%	24
Reduce sediment loss	1200	2%	24
Liming	1200	5%	60
Combined benefits			**$45/ha/year**

6.3.5 Private Cost-Benefits of CSHS Farm Practices

The annual net private benefit of CSHS farm practices for dairy is shown in Table 6-13

Table 6-13: Annualised Cost and Benefit of CSHS Farm Practices for Dairy

	$/ha/year
Combined cost	$35.3
Combined benefit	$45
Net Benefit	$9.7

6.3.6 Adoption rates

Adoption rates have been estimated from CSHS working group estimates combined with RMCG experience. Resulting estimates were then checked against likelihood tables produced from the DPI land Use Impact Model (LUIM).

This checking involved comparison of the spatial distribution of the likelihood of soil degradation processes (equivalent to the soil issues presented in section 3) that each practice addressed to the area that practices would be adopted given assumed adoption rates. Adoption rates were adjusted if a significant discrepancy was found.

Long term trends in ABS data were used to determine the future total area for dairy.

Assumed adoption rates for the no intervention scenario are presented in Table 6-14. The no intervention scenario is what we would expect to occur without CSHS. It is the baseline to compare CSHS actions against.

Table 6-14: Land Areas of Farm Practices Given No Intervention

Farm Practice	Current Adoption. (% of cropping area)	% Increase Each Year Given No Intervention	Area (ha)			
			2003	2013	2023	2033
Total area		1.3%	171,004	194,581	221,409	251,935
Drainage & grazing management	30%	0.5%	51,301	53,925	56,682	59,581
Fertiliser management	30%	0.5%	51,301	53,925	56,682	59,581
Effluent reuse	15%	2%	25,651	31,268	38,115	46,462
Reduce machinery compaction	3%	2%	5,130	6,254	7,623	9,292
Reduce sediment loss	3%	1%	5,130	5,667	6,260	6,915
Liming	45%	1%	76,952	85,003	93,896	103,719
Combined	**21%**	**1.2%**	**35,911**	**40,327**	**45,287**	**50,857**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and ideally would require surveying for verification.

Assumed adoption rates for the combined soil health actions are presented in Table 6-15.

Table 6-15: Land Areas of Farm Practices Given Implementation of CSHS

Farm Practice	Strategy adoption Rates (% per yr)	Area (ha)			
		2003	2013	2023	2033
Total area	1.3%	171,004	194,581	221,409	251,935
Drainage & grazing management	2%	51,301	62,536	76,231	92,925
Fertiliser management	2%	51,301	62,536	76,231	92,925
Effluent reuse	6%	25,651	45,936	82,265	147,324
Reduce machinery compaction	10%	5,130	13,306	34,513	89,517
Reduce sediment loss	9%	5,130	12,145	28,751	68,065
Liming	3%	76,952	103,417	138,983	186,782
Combined	**5.3%**	**35,911**	**60,379**	**101,518**	**170,687**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and depend upon the level of extension, economic conditions and effectiveness of CSHS.

The CSHS is likely to result in a considerable increase in the proportion of the total dairy area that implements the CSHS farm practices. Given assumed adoption rates, the percentage of land that on which combined practices occur could increase from 20 per cent given no intervention to 70 per cent with CSHS intervention.

This scenario is considered to be a maximum change scenario; in reality adoption rates are likely to be significantly less than presented above. Refer to Appendix C for a discussion of likely adoption rates.

6.3.7 Total private benefit of soil health

The total net benefit of the soil health actions are presented below. These amounts have been calculated by multiplying the per hectare costs and benefits by the area of the relevant production system (hectares). This results in a total dollar figure for the costs, benefits and net benefits to be expected for the combined on-farm practices of the strategy.

The baseline no intervention scenario is compared with the predicted amounts calculated for the implementation of the CSHS. This produces the expected costs and benefits that can be attributed solely to the implementation of the CSHS.

Table 6-16 presents the cost and benefit amounts for the no intervention scenario.

Table 6-16: Benefits of no intervention for dairy

	2003	2013	2023	2033
Total Cost	$ 1,268,688	$ 1,424,720	$ 1,599,940	$ 1,796,711
Total Benefit	$ 1,615,986	$ 1,814,730	$ 2,037,917	$ 2,288,553
Net Benefit	**$ 347,298**	**$ 390,011**	**$ 437,977**	**$ 491,842**

Table 6-17 presents the cost and benefit amounts for the strategy being implemented.

Table 6-17: Benefits of CSHS actions

	2003	2013	2023	2033
Total Cost	$ 1,268,688	$ 2,133,110	$ 3,586,506	$ 6,030,174
Total Benefit	$ 1,615,986	$ 2,717,040	$ 4,568,297	$ 7,680,908
Net Benefit	**$ 347,298**	**$ 583,930**	**$ 981,791**	**$ 1,650,734**

Table 6-18 presents the net cost and benefit amounts for the CSHS for dairy.

Table 6-18: Net Benefit of CSHS Actions

	2003	2013	2023	2033
Total Cost	$ -	$ 708,390	$ 1,986,566	$ 4,233,463
Total Benefit	$ -	$ 902,309	$ 2,530,379	$ 5,392,355
Net Benefit	**$ -**	**$ 193,919**	**$ 543,814**	**$ 1,158,892**

A total on-farm net benefit of over on million dollars may be expected through the implementation of the CSHS.

Table 6-19 shows the net present value of implementing the CSHS for dairy at an 8 per cent discount rate over 30 years. This is the difference between the present value of net benefits *with* and *without* the CSHS.

Table 6-19: Net Present Value of CSHS on Dairy

	Present Value @ 8% discount over 30 years ($'000)
With CSHS	$7,239
Without CSHS	$4,418
Net Present Value	$2,820

6.4 Broad Acre Grazing Production Systems

The CSHS programs relevant are:

- Encourage graze and spell (rotation) based on understanding of plant and soil needs (Action 4.1);
- Promote appropriate rate/type of nutrients/lime to match grazing demand (Action 4.2);
- Promote the fencing of different land classes to allow appropriate grazing (Action 4.3);
- Strategically establish trees to act as windbreaks to control wind erosion (Action 4.4); and
- Increase the establishment of perennial pastures, with a preference for direct drilling (Action 4.5).

6.4.1 Private Costs

Encourage graze and spell (rotation) based on understanding of plant and soil needs

The grazing working group has estimated the on-farm costs for rotation grazing to be $25/ha plus increasing stock numbers.

Promote appropriate rate/type of nutrients/lime to match grazing demand

The grazing working group has stated that there are no real costs associated with lime and nutrient management and that an open mind is all that is needed.

SGS data suggests that many farmers are not currently testing their soils for nutrient levels. This practice could significantly improve nutrient and lime management.

Soil testing costs of $3/ha/year have been assumed for nutrient management actions. This has been estimated from RMCG client records. This figure is equivalent to the difference in costs between the lowest and highest income earners amongst Victorian wool growers (NRE,1999).

Promote the fencing to allow appropriate grazing of different land classes

The grazing working group has estimated a capital cost of $60/ha for the required fencing (1000m/100ha) which is $7.5/ha/year assuming 8 per cent interest and the need for replacement after 15 years.

Additional operating costs of $5/ha/year can be expected due to water pumping as well as management and labour demands.

Therefore total additional costs for land class fencing are $12.5/ha/year.

Strategically establish trees to act as windbreaks to control wind erosion

The grazing working group has estimated a cost of $35 per hectare for establishing 10 per cent tree cover which is $3.8/ha/year assuming 8 per cent interest and replacement after 20 years.

Increase the establishment of perennial pastures, with a preference for direct drilling

Costs of $125/ha for perennial pasture establishment have been determined from RMCG client records which is $19.73/ha/year assuming 8 per cent interest and replacement after 10 years.

6.4.2 Total Private Cost

The sum of the costs for the individual actions amounts to approximately $64/ha/year. The sum of the costs is unlikely to be an effective measure of total costs due to inherent efficiencies in undertaking actions concurrently.

Also, in practice it is likely that land managers will implement the actions in stages or only adopt some of the actions.

Therefore this study has averaged the costs for each action and adopted this average as a likely combined cost of actions for land managers. The costs and combined adopted cost are presented in Table 6-20.

Table 6-20: Total Private Costs for Grazing

Action	Annual Capital Cost	Additional Annual Operating Cost	Total Additional Annual Costs
	$/ha/yr	$/ha/yr	$/ha/yr
Rotation grazing	0.0	25	25.0
Lime/fertiliser management	0.0	3	3.0
Land class fencing	7.5	5	12.5
Trees as windbreaks	3.8	0	3.8
Introduce perennials (where absent)	19.7	0	19.7
Adopted combined improved practice			**$13/ha/yr**

6.4.3 Private Benefits

Encourage graze and spell (rotation) based on understanding of plant needs

Southern Grazing Systems (2001) research indicates that significant increases in gross margins can be achieved through the adoption of rotation grazing.

Research in south western Victoria has shown the rotation grazing can allow a 10-15 per cent increase in stocking rates. An increase in production of 15 per cent has been assumed by this study.

Promote appropriate rate/type of nutrients/lime to match grazing demand

The SGS program found that less than $0.50/ha/year of P fertiliser equivalent is being lost in surface water runoff. Therefore on-farm benefits resulting from restricting nutrient run off are minor.

Appropriate liming and fertiliser application can significantly increase soil fertility and pasture productivity. This can result in increase in stocking rates.

Benefits of lime and nutrient management are assumed to be a 5 per cent increase in production.

Promote the fencing to allow appropriate grazing of different land classes

Land class fencing can result in significant reduction in soil erosion, soil compaction and impacts from stock camps.

On-farm financial benefits of reduced soil erosion and compaction are difficult to quantify. They are experienced through improved pasture growth and subsequent increased stocking rates. It has been assumed that an improvement of 7 per cent be achieved through land class fencing.

Strategically establish trees to act as windbreaks to control wind erosion

Windbreaks can contribute to on-farm financial benefits by improving pasture and crop production and decreasing the cost of chemical control of pests.

Pasture and crop improvements are likely to contribute to a 2 per cent increase in production. Decreases in chemical costs are considered to be minimal.

Increase the establishment of perennial pastures, with a preference for direct drilling

The introduction of perennial pastures can result in significant increases in production and gross margins. Previous studies by RMCG (2002) indicate increases can be up to 8 dse/ha when combined with liming and improved grazing management.

Stocking rates are unlikely to increase by more than 6 dse/ha (50 per cent) and this is only likely from areas of existing low stocking rates.

An increase in production of 10 per cent has been assumed to result from the addition of perennials.

6.4.4 Combined Private Benefits

The benefits of the strategy action cannot simply be summed as the full benefit of each action may not be realised if other actions have been/are adopted.

Therefore this study has averaged the benefits for each action and adopted this average as a likely combined benefit. The benefits and combined adopted cost are presented in Table 6-21.

Table 6-21: Combined Benefits of CSHS for Grazing

Action	Current Gross Income	Production Increase	Increase in Gross Income
Rotation grazing	240	15%	36
Lime/fertiliser management	240	5%	12
Land class fencing	240	7%	16.8
Trees as windbreaks	240	2%	4.8
Introduce perennials (where absent)	240	10%	24
Combined benefits			**$19/ha/year**

6.4.5 Private Cost-Benefits of CSHS Farm Practices

The annual net private benefit of CSHS farm practices for broad acre grazing is shown in Table 6-22.

Table 6-22: Cost and Benefit of CSHS farm practices for broad acre grazing

	$/ha/year
Combined Cost	$13
Combined Benefit	$19
Net Benefit	$6

6.4.6 Adoption rates

Adoption rates have been estimated from CSHS working group estimates combined with RMCG experience. Resulting estimates were then checked against likelihood tables produced from the DPI land Use Impact Model (LUIM).

This checking involved comparison of the spatial distribution of the likelihood of soil degradation processes (equivalent to the soil issues presented in Section 3) that each practice addressed to the area that practices would be adopted given assumed adoption rates. Adoption rates were adjusted if a significant discrepancy was found.

Long term trends in ABS data were used to determine future areas for cropping and dairy. It has been assumed that increases in these land uses result in a decrease in the total area of grazing.

Assumed adoption rates for the no intervention scenario are presented in Table 6-23. The no intervention scenario is what we would expect to occur without CSHS. It is the baseline to compare CSHS actions against.

Table 6-23: Land Areas of Farm Practices Given No Intervention

Farm Practice	Current Adoption. (% of cropping Area)	% Increase Each year Given no Intervention	Area (ha)			
			2003	2013	2023	2033
Total area			732,944	696,902	656,446	611,013
Rotation grazing	35%	0.5%	256,530	269,649	283,439	297,934
Lime/fertiliser management	10%	0.5%	73,294	77,042	80,982	85,124
Land class fencing	3%	0.1%	21,988	22,209	22,432	22,657
Trees as windbreaks	10%	2%	73,294	89,345	108,911	132,762
Introduce perennials (where absent)	20%	1.0%	146,589	161,925	178,866	197,580
Combined	**16%**	**0.8%**	**114,339**	**124,068**	**134,626**	**146,081**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and ideally would require surveying for verification.

Assumed adoption rates for the combined soil health actions are presented in Table 6-24.

Table 6-24: Land Area of Farm practices given CSHS Implementation

Farm Practice	Strategy adoption Rates (% per yr)			Area (ha)			
	2003-13	2013-23	2023-33	2003	2013	2023	2033
Total area				732,944	664,206	570,528	441,048
Rotation grazing	7.5%	0%	0%	256,530	528,716	513,475	396,943
Lime/fertiliser management	22.0%	0%	0%	73,294	535,386	513,475	396,943
Land class fencing	27.5%	0.1%	0.01%	21,988	249,625	252,132	252,384
Trees as windbreaks	5%	2%	1%	73,294	119,388	145,534	160,760
Introduce perennials (where absent)	2.0%	1.3%	0.4%	146,589	178,691	203,328	211,609
Combined	**12.8%**	**0.7%**	**3.2%**	**114,339**	**381,316**	**408,054**	**396,943**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and depend upon the level of extension, economic conditions and effectiveness of CSHS.

The above tables highlight the fact that grazing is the one land use in the CCMA that is expected to significantly decrease in size, irrespective of CSHS implementation. The CSHS can be expected to increase this decline in area as well as significantly increasing the proportional area of CSHS farm practices being adopted.

6.4.7 Total Private Benefit of CSHS Farm Practices

The total net benefit of the soil health actions are presented below. These amounts have been calculated by multiplying the per hectare costs and benefits by the area of the relevant production system (hectares). This results in a total dollar figure for the costs, benefits and benefits-costs to be expected for the combined on-farm practices of the strategy.

The baseline no intervention scenario is compared with the predicted amounts calculated for the implementation of the CSHS. This produces the expected costs and benefits that can be attributed solely to the implementation of the CSHS.

Table 6-25 presents the cost and benefit amounts for the no intervention scenario

Table 6-25: Benefits of no intervention

	2003	2013	2023	2033
Total Cost	$1,464,626	$1,589,255	$1,724,489	$1,871,231
Total Benefit	$2,140,426	$2,322,561	$2,520,195	$2,734,645
Net Benefit	**$675,800**	**$733,306**	**$795,705**	**$863,414**

Table 6-26 presents the cost and benefit amounts for the strategy being implemented.

Table 6-26: Benefits of CSHS actions

	2003	2013	2023	2033
Total Cost	$1,464,626	$4,884,473	$5,226,967	$5,084,642
Total Benefit	$2,140,426	$7,138,241	$7,638,768	$7,430,772
Net Benefit	**$675,800**	**$2,253,769**	**$2,411,801**	**$2,346,130**

Table 6-27 presents the net cost and benefit amounts for the CSHS for grazing

Table 6-27: Net Benefit of CSHS Actions

	2003	2013	2023	2033
Total Cost	$ -	$3,295,217	$3,502,477	$3,213,411
Total Benefit	$ -	$4,815,680	$5,118,573	$4,696,127
Net Benefit	**$ -**	**$1,520,463**	**$1,616,096**	**$1,482,716**

An on-farm net benefit of just over one million dollars may be expected through the implementation of the CSHS.

Table 6-28 shows the net present value of implementing the CSHS for broadacre grazing at an 8 per cent discount rate over 30 years. This is the difference between the present value of net benefits *with* and *without* the CSHS.

Table 6-28: Net Present Value of CSHS on Broad acre Grazing

	Present Value @ 8% discount over 30 years ($'000)
With CSHS	$19,394
Without CSHS	$8,285
Net Present Value	$11,109

6.5 Private Plantation and Farm Forestry

The relevant Corangamite Soil Health Strategy actions for block plantations on sloping sites are:

- Implement the Codes of Forest Practices for Timber Production (Action 7.1)
- Promote forestry plantations in areas that benefit soil and catchment health (Action 7.3); and
- Develop a discussion group to improve the implementation of private forestry BMPs (Action 7.4).

Assumptions

Some key assumptions used in the evaluation of the Soil Health Strategy Actions for private and farm forestry are:

- The typical species and rotation mix is 60 per cent Radiata Pine and 40 per cent Blue gum;
- Rotation length for Radiata Pine and Blue gum is 28 years and 20 years respectively; and
- Current annual growth in plantations in the region of 260 hectares of softwood and 500 hectares of hardwood (including farm forestry).

Many of the assumptions concerning the current costs of operations, likely impacts of CSHS actions on production and adoption rates of the best management practices with and without the actions have been formulated by URS in the absence of better information being provided by industry 'experts'. These assumptions are likely to have considerable influence on private costs and benefits and will need to be reviewed if and when better information becomes available. For more assumptions, see Appendix D.

6.5.1 Private costs

Implement Code of Forest Practices

The Code of Forest Practices formalises the best management practices, from site preparation to post-harvest practices, for forest activities. The Code is enforced on public land, but while it incorporates management practices on private land, it is simply a guideline rather than regulation on this land. For this assessment, the management practices specified in the Code of Forest Practices that have been evaluated are:

- ground preparation (including appropriate ripping and mounding); and
- road design, construction and maintenance.

Ground Preparation

Best management practices for ground preparation which includes contour ripping and mounding is estimated to increase site preparation costs by around 25 per cent. This includes the possible increase in time and labour input, equipment hire and other costs. Assuming an average cost of site preparation of $190 per hectare, the additional cost of best management ground preparation is approximately $47.50 per hectare. This cost will be incurred on new sites or existing site re-establishment for the areas where the action is adopted.

Roading and other costs

Additional private costs identified include code adherence costs of up to $100 per hectare which includes improved road design and construction. This cost is assumed to be incurred once for each rotation.

Table 6-29: Private Cost of Implementing the Code of Forest Practices on private plantation and farm forestry

Action	Average Cost $/ha	Frequency of Outlay
Ripping and Mounding	$47.50	Once at plantation establishment
Additional costs (eg. Roads)	$100	Assume once in year before final harvest
Total Annual Equivalent Cost (calculated over 30 years @ 8%)	$6.41	

Promote plantations in areas that benefit soil and catchment health

Establishing plantations in marginal areas that benefit soil and catchment health are often not the preferred sites for optimal tree growth rates. Private establishment and management costs for plantations located on target sites is estimated to increase by around 50 per cent of the total cost (estimated at $1,200 per hectare), or around $600 per hectare over the first three years of the rotation, giving a total establishment cost of $1,800 per hectare. This translates into an annual private cost of $52 per hectare per year calculated at 8 per cent discount rate.

Table 6-30: Private Cost of establishing plantations on areas that benefit soil and catchment health on private plantation and farm forestry

Action	Average Cost $/ha	Frequency of Outlay
Additional costs	$600	Once every rotation
Annual Equivalent Cost (calculated over 30 years @ 8%)	$52[a]	

[a] Assumes a rotation length of 20 years for hardwood (40%) and 28 years for softwood (60%) plantations

6.5.2 Private benefits

Implement Code of Forest Practices

The private benefits for ripping and mounding include higher product yields and greater seedling success rates. Better seedling success rates will increase the volume of the first thinning and implicitly increase the value of clearfall products by providing greater selection ability at thinning. The average increase in production value was estimated at 15 per cent or $21/ha/year (15% of $140/ha).

Better road design and construction may decrease road maintenance costs by 25 per cent. At a current average annual road maintenance cost of $100 per hectare, the benefit of this BMP is estimated at $25/ha/year.

Future plantation establishment costs (other than road design and construction) may also be reduced through adherence to the Code of Forest Practices. Assuming a current establishment cost of $1,200 per hectare and a reduction in future establishment costs of 10 per cent, the reduction in future establishment costs are $120/ha. This translates to an average annual equivalent saving of around $1.50/ha/year.

Table 6-31: Private Benefit of implementing Code of Forest Practices on private plantation and farm forestry

Action	Average Benefit $/ha/yr
Ripping and Mounding	$21
Better Road Construction	$25
Reduced Future Establishment Costs	$1.53
Annual Equivalent Benefit (calculated over 30 years @ 8%)	$47.53

Promote plantations in areas that benefit soil and catchment health

The private benefits for establishing plantations in areas that benefit soil and catchment health include the opportunity cost of alternative land uses. Although the productivity of plantations are likely to be less than that achievable on more suitable sites for tree growing, the annual equivalent returns on the target land may be in the order of $140 per hectare per year[1]. Sheep grazing in these low production areas are around, say, 10 DSE per hectare[2], which translates into an average gross margin of $120 per hectare (based on a gross margin for sheep grazing of $12 per DSE[3]). The difference between these land uses, $20 per hectare, represents the productivity benefits of this action.

The CSHS Working Group suggested a likely reduction in annual maintenance costs normally associated with inappropriate land use. This reduction may be in the order of 50 per cent of current annual maintenance costs of $50 per hectare. This equates to an annual reduction in maintenance costs of $25 per hectare per year.

Table 6-32: Private Benefit of establishing plantations on areas that benefit soil and catchment health on private plantation and farm forestry

Action	Average Benefit $/ha/yr
Net productivity	$20
Reduced maintenance	$25
Annual Equivalent Benefit (calculated over 30 years @ 8%)	$45

[1] Based on average returns for a combination of softwood and Blue gum woodlots (URS, 2003).
[2] Based on a low Victoria average sheep stocking rate of 1.4 DSE/ha/100mm rainfall and around 700mm rainfall.
[3] Based on a low Victorian average gross income of $20 per DSE and sheep variable costs of around $8 per DSE.

6.5.3 Net Benefits

Table 6-33 shows that Action 7.1 may require Government incentives to encourage landholders to develop woodlots on sites that would benefit soil and catchment health. That is, the additional establishment costs are greater than the private benefits that would result. On the other hand, Action 7.3 is likely to result in a net private benefit and hence, be more readily adopted by landholders.

Table 6-33: Annualised Private Costs and Benefits of the CSHS actions for Private plantation and farm forestry ($/ha/year)

	Action 7.3	Action 7.1
Combined Private Cost	$51.89	$6.41
Combined Private Benefit	$45.00	$47.53
Net Private Benefit	-$6.89	$41.12

6.5.4 Adoption rates

In estimating the total benefits of the Corangamite Soil Health Strategy, estimates were made for the likely adoption of relevant actions, 'with' and 'without' the soil health strategy. Resulting estimates were then checked against likelihood tables produced from the DPI land Use Impact Model (LUIM). This checking involved comparison of the spatial distribution of the likelihood of soil degradation processes (equivalent to the soil issues presented in Section 3) that each practice addressed to the area that practices would be adopted given assumed adoption rates. Adoption rates were adjusted if a significant discrepancy was found.

The benefits associated with Action 7.4 listed above, to develop a discussion group to improve the implementation of private forestry BMPs, has been incorporated into the benefit cost analysis by increasing the rate of adoption of the other actions evaluated in this report. The CSHS Working Group suggested that this action could increase the adoption of actions 7.1 and 7.3 by 0.5 per cent.

Assumed adoption rates for the no intervention scenario are presented in Table 6-34. The current total area of private plantation forestry plus private farm forestry is estimated at 51,350 hectares (URS Forestry, 2003). This area may differ from that presented in Table 2-1 as these have been derived from different sources and the areas of private and public forestry from URS Forestry (2003) were considered to be the most accurate. The no intervention scenario is what we would expect to occur without CSHS. It is the baseline to compare CSHS actions against.

Table 6-34: Land Areas of Farm Practices Given No Intervention

Farm Practice	Current Adoption. (% of private forest Area)	% Increase Each year Given no Intervention	Area (ha)			
			2003	2013	2023	2033
Total area		0.5%	51,350	53,976	56,736	59,638
Planting Marginal Sites	10%	0.1%	5,135	5,187	5,239	5,291
Implement COFP	30%	1.0%	15,405	17,017	18,797	20,764
BMP Discussion Groups	0%	0%	na	na	na	na
Combined		**0.4%**	**10,270**	**10,688**	**11,124**	**11,577**

Note: These are estimates based on CSHS working group estimates. However they are very approximate estimates and ideally would require surveying for verification.

Assumed adoption rates for the soil health actions are presented in Table 6-35.

Table 6-35: Land Area of Farm practices given CSHS Implementation

Farm Practice	Strategy adoption Rates (% per yr)	Area (ha)			
		2003	2013	2023	2033
Total area	0.5%	51,350	53,976	56,736	59,638
Planting Marginal Sites	1.0%	5,135	5,959	6,916	8,026
Implement COFP	5.6%	15,405	27,849	50,347	59,638
BMP Discussion Groups	0.5%	na	na	na	na
Combined	**2.4%**	**10,270**	**13,624**	**18,074**	**23,978**

Note: These are estimates based on CSHS working group estimates. However they are very approximate estimates and depend upon the level of extension, economic conditions and effectiveness of the CSHS.

In the above tables, the future growth in private forestry is assumed to occur at the expense of area currently used for broadacre grazing. The figures highlight the fact that extent of private forestry in the CCMA is likely to increase irrespective of CSHS implementation. The CSHS can be expected to have little or no effect on overall growth in private forestry, but will increase the adoption of best management forestry practices. It should be noted that the adoption of plantations on marginal sites with the CSHS (around 80 hectares per year in the first 10 years) is considered to a high estimate of achievable adoption.

6.5.5 Total Private Benefit of CSHS Farm Practices

The total net benefit of the soil health actions are presented below. These amounts have been calculated by multiplying the per hectare costs and benefits by the area of the relevant production system (hectares).

This results in a total dollar figure for the costs, benefits and benefits-costs to be expected for the combined on-farm practices of the strategy.

The baseline no intervention scenario is compared with the predicted amounts calculated for the implementation of the CSHS. This produces the expected costs and benefits that can be attributed solely to the implementation of the CSHS.

Table 6-36 presents the cost and benefit amounts for the no intervention scenario

Table 6-36: Benefits of no intervention

	2003	2013	2023	2033
Total Cost	$598,788	$623,175	$648,556	$674,970
Total Benefit	$950,280	$988,983	$1,029,262	$1,071,181
Net Benefit	**$351,492**	**$365,808**	**$380,706**	**$396,211**

Table 6-37 presents the cost and benefit amounts for the strategy being implemented.

Table 6-37: Benefits of CSHS actions

	2003	2013	2023	2033
Total Cost	$598,788	$794,364	$1,053,820	$1,398,019
Total Benefit	$950,280	$1,260,661	$1,672,418	$2,218,664
Net Benefit	**$351,492**	**$466,297**	**$618,599**	**$820,646**

Table 6-38 presents the net cost and benefit amounts for the CSHS for grazing

Table 6-38: Net Benefit of CSHS Actions

	2003	2013	2023	2033
Total Cost	$ -	$171,189	$405,264	$723,049
Total Benefit	$ -	$271,678	$643,157	$1,147,483
Net Benefit	**$ -**	**$100,489**	**$237,892**	**$424,434**

Table 6-39 shows the net present value of implementing the CSHS for private forestry at an 8 per cent discount rate over 30 years. This is the difference between the present value of net benefits *with* and *without* the CSHS.

Table 6-39: Net Present Value of CSHS on Private Forestry

	Present Value @ 8% discount over 30 years ($'000)
With CSHS	$5,409
Without CSHS	$4,123
Net Present Value	$1,286

6.6 Public Native Forestry

The relevant Corangamite Soil Health Strategy actions are:

- Ensure timber operations continue to comply with the Code of Forest Practices; and
- Increase awareness and skills in road design construction and maintenance.

Code of Forest Practices is already enforced on Public land. Adherence to the code of practice would ensure that site and temporary road regeneration is undertaken in a manner that maximises future environmental condition. Also, changes in the management of public native forests in the Corangamite Region are proposed over the next 5 years or so. Therefore, the costs and benefits from implementing the soil health strategy have not been evaluated.

6.7 Sum of Net Benefits for all Production Systems

Table 6-40 shows the sum of the net benefits for all production systems evaluated in this assessment. The figures show that the total on-farm net benefits can reach just under $2.5 million per year within 10 years and just over $8 million per year within 30 years with the implementation of all of the CSHS actions.

Table 6-40: Sum of Net Benefits for all production systems

Production System	2003	2013	2023	2033
Cropping	$ -	$ 625,410	$ 2,036,323	$ 5,039,521
Dairy	$ -	$ 193,919	$ 543,814	$ 1,158,892
Grazing	$ -	$ 230,039	$ 559,791	$ 1,026,908
Private Forestry	$ -	$100,489	$237,892	$424,434
Public Native Forestry		Not assessed		
Total		**$2,440,146**	**$4,433,687**	**$8,104,480**

7.1 Acid Sulfate Soils

Some possible management actions that can be considered to address potential acid sulfate soils may include:

- Avoid disturbance of potential ASS - Given that potential ASS are harmless while remaining saturated, the best defence from the development of ASS is to avoid disturbance. That is, being aware of the occurrence of potential ASS and taking the appropriate steps not to expose or drain these soils. Acid sulfate soil hazard maps have been developed for Victoria, which can be utilised when development approval (such as for construction of deep drains, roads, buildings, bridges, pipelines) is being sort in coastal areas;
- Re-cover potential ASS if exposed and take measures to ensure it remains wet;
- Apply lime to ASS (eg. in deep channels) to neutralise the acid (if ASS occurs); and
- Submerge ASS with freshwater to prevent oxidisation or flush soils with seawater to neutralise acid.

The CSHS Working Group have provided no management actions, with costs and benefits, associated with managing acid sulfate soils. Therefore, it was not possible to undertake benefit cost analysis for acid sulfate soils.

Most ASS in the Corangamite region are present in thin layers with some level of sea shell deposits which is likely to neutralise any sulphuric acid released by ASS (Austin Brown, DPI, pers. comm.). Due to there being little or no ASS exposed in the Corangamite Region to date, coupled with the growing awareness of the potential threats and occurrence of ASS, the likelihood of future oxidisation of ASS is relatively low.

The potential consequences of oxidisation of ASS are not well understood for the Corangamite, however, the Tuckean Swamp in New South Wales (where sulphuric acid is released from ASS) may be viewed as an indication of the potential environmental, economic and social benefits that can be derived from managing ASS. Read Sturgess and Associates (1996) estimated that for the best outcome, management of ASS around the Tuckean Swamp can produce a net present value of total benefits of greater than $15.5million.

The Tuckean Swamp study considers the benefits of managing the consequences of waterway acidification from ASS, whereas, in the Corangamite, the main actions would be focussed on managing the likelihood of acidification occurring in the first place. Nevertheless, it could be said that the present value of the *impact* on the Tuckean Swamp from ASS could be greater than $15.5 million, which may provide an indication of the magnitude of the potential value of preventing acidification occurring in the Barwon Estuary.

7.2 Landslides

The landscapes of the CCMA region are among the most landslide prone in Australia. Whilst no timeframe was specified, over 1,480 landslides were identified as being mapped in a background paper as part of the CSHS (Dahlhaus Environmental Geology 2003). Within this background report, the size of landslides were also described as varying from a few square metres to over 120 hectares, and in volume from a few cubic metres to over ten million cubic metres. Extreme rainfall is the dominant trigger for landslides in the CCMA region.

Landslides and erosion pose risks to infrastructure assets, water quality assets, agricultural assets, environmental assets, and human life. In developing the CSHS, information was collected on the occurrence and associated consequences of a range of landslides in the region over the past 50 years (Dahlhaus Environmental Geology 2003). The consequences that were documented for individual landslides ranged between \$20,000 and \$500,000 for damage primarily to municipal infrastructure. It is likely that these estimates substantially under-estimate the total risks (economic, social and environmental) associated with these landslides.

Information was provided on the 'do nothing' probability of a given landslide impacting on an asset (Dahlhaus Environmental Geology 2003). This data is reproduced in Table 7-1.

Table 7-1: The relative likelihood of landslides having different types of consequences 'without the CSHS'.

Type of Consequence	Probability
Catastrophic Damage to environmental assets (eg Lake Elizabeth)	0.002
Loss of Life	0.02
Catastrophic Damage to Infrastructure Assets (Eg buildings destroyed)	0.04
Major damage to Infrastructure Assets (eg Section of Road Destroyed)	0.1
Medium Damage to Infrastructure Assets, environmental assets (eg Pipeline stabilisation works)	0.2
Minor damage to all classes of assets (eg Road closed for a day)	1

The management of landslides requires a landslide risk assessment to be completed to ensure that priority areas (where the risk to assets including human life is greatest) are targeted for management. Within the CSHS, we have included costs to achieve the following management options:

- encourage the implementation of uniform standards for landslide risk management;
- develop and encourage adoption of a landslide risk management process for all works; and
- develop and implement a community education and awareness program on landslide risk management.

With these management actions, it was estimated by Dahlhaus (2003) that the probabilities shown in Table 7-1 could be reduced by "one of more orders of magnitude". With a more conservative assumption that the likelihood of these consequences are halved, and the consequences shown in Table 7-2, we have estimated the annual benefits of landslide management. No risks have been quantified for catastrophic damage to environmental assets or losses in human life. Where these risks are quantified, the benefits of landslide management could be substantially higher than those calculated below.

Table 7-2: The costs associated with different types of consequences for landslides.

Type of Consequence	$
Catastrophic Damage to environmental assets (eg Lake Elizabeth)	Very High
Loss of Life	Very High
Catastrophic Damage to Infrastructure Assets (Eg buildings destroyed)	$500,000
Major damage to Infrastructure Assets (eg Section of Road Destroyed)	$150,000
Medium Damage to Infrastructure Assets, environmental assets (eg Pipeline stabilisation works)	$50,000
Minor damage to all classes of assets (eg Road closed for a day)	$10,000

With an estimated 20 landslides per year, the annual benefits of landslide management are estimated at $550,000 per year. If we assume that these benefits are progressively realised over a 10-year period, the present value of benefits at 8 per cent over 30 years is equal to $4.3 million.

Table 7-3: Benefits associated with landslide management in the CSHS.

Consequences	Consequence (50th percentile)	Likelihood (without)	Likelihood (with)	Benefit per landslide	Total
Catastrophic Damage to environmental assets (eg Lake Elizabeth)	Very High	0.002	0.0002	Not estimated	Not estimated
Loss of Life	Very High	0.02	0.002	Not estimated	Not estimated
Catastrophic Damage to Infrastructure Assets (Eg buildings destroyed)	$500,000	0.04	0.02	$10,000	$200,000
Major damage to Infrastructure Assets (eg Section of Road Destroyed)	$150,000	0.1	0.05	$7,500	$150,000
Medium Damage to Infrastructure Assets, environmental assets (eg Pipeline stabilisation works)	$50,000	0.2	0.1	$5,000	$100,000
Minor damage to all classes of assets (eg Road closed for a day)	$10,000	1	0.5	$5,000	$100,000
Total					$550,000

7.3 Coastal Dune Movement

No information could be found on the current extent of the problem in the CCMA region, hence no costs or benefits were quantified.

7.4 Benefits from Improved Water Quality

With the various actions proposed in the Corangamite Soil Health Strategy, landholders will reduce the amount of nutrients that enter waterways above and beyond that happening with the Corangamite Regional Nutrient Management Plan.

7.4.1 Reduction in Nutrient Export

Background

The costs and benefits of nutrient management were assessed for the Corangamite region in the regions Nutrient Management Plan. The quantitative analysis of the benefits of nutrient management was limited to evaluating the reduction in expected value of damages from toxic blue-green algal blooms. These benefits included both priced and unpriced use values, where the latter involved recreational benefits. It is important to note that unpriced non-use values, such as improvements in wildlife habitat due to improved water quality were not quantified in that analysis. These benefits have the potential to be large (Read Sturgess and Associates 1998).

The impacts were quantified for all those who enjoy values associated with the waterbodies and waterways; namely:

- visitors to waterbodies and waterways for recreation;
- farmers relying on stock water;
- users of domestic water;
- industrial users of water;
- urban users of water;
- irrigators;
- fishermen; and
- home owners with amenity values.

The benefits of nutrient management were estimated by:

1. determining the expected impacts of blooms without a nutrient management strategy; then
2. multiplying by the expected percentage reduction in the number of blooms that would be achieved by implementing each nutrient management activity.

The expected impact of blooms without a nutrient management plan was estimated at between $5.7 and $9.2 million annually. With the nutrient management plan it was estimated that the occurrence of toxic algal blooms could be reduced by 46 per cent. For more information on the estimation of impacts and benefits for the Corangamite Regional Nutrient Management Strategy, readers are directed to the full economic report (Read Sturgess and Associates 1998).

The quantified annual benefits of nutrient management within the Corangamite region are shown in Table 7-4.

Table 7-4: Benefits and Costs of the Corangamite Regional Nutrient Management Strategy ($ million)

	Present value (8 per cent over 30 years)	
	Low Estimate	**High Estimate**
Benefits $M	$40	$80
Costs $M	$40	$40
Net Present Value	$0	$40
Benefit Cost Ratio	1	2

The management actions included within the nutrient management strategy include:

- fencing off streams to provide filter strips that would intercept nutrient laden runoff;
- effective dairy waste management; and
- soil stabilisation measures to minimise nutrient loss.

Economic benefits of the Soil Health Strategy

Liming acid soils, applying gypsum, establishing deep rooted pasture species, and improving grazing management are all likely to reduce erosion and, therefore, reduce the amount of nutrient exported from agricultural land in the Corangamite region. Any increase in rates of adoption for these management actions due to the CSHS will therefore have economic benefits for the region.

To estimate the change in the timing and achievement of nutrient reduction across the Corangamite region due to the CSHS is a major task that is beyond the scope of this benefit cost analysis. To undertake such an assessment, we would need to review management actions and rates of adoption within the nutrient management strategy, isolate the source of nutrient loads throughout the catchment, and identify new/existing management actions that change the timing of benefits.

Whilst approximately 50 per cent of nutrients in the Corangamite are sourced from agricultural land, more recent work completed by the consultants has shown that the proportion of these nutrients that is directly manageable from on-farm management actions may be less than 40 per cent. Within the Upper North East Water Quality Strategy, regional experts estimated that the greatest source (55 per cent) of nutrients was stream banks and instream processes (UNEWQS 1998).

7.4.2 Reduction in Sediment Export

The Draft Waterway Health Strategy was developed for the CCMA in 2001. Since this time, substantial effort has gone into developing a decision support tool 'RiVERS' to prioritise investments in waterways as part of a River Health Strategy. The Draft River Health Strategy has presently identified priority waterways for management and should be finalised by June 2004 (Greg Peters, pers comm.).

Whilst no management actions within the CSHS have been developed to specifically target priority waterways, or achieve river health benefits, any actions that reduce erosion will have secondary benefits associated with waterways.

It is likely that the net benefits from works to reduce soil health impacts will be greatest in areas that are close to waterways with high values (economic, social and environmental). Within the soil health strategy, these off-site/downstream benefits should be recognised.

It was not possible to quantify any benefits or costs associated with a reduction in the export of sediments as part of this assessment. To undertake such an assessment, we would require information on the location of priority waterways, the extent with which sediment threaten river health benefits, and the ability of management actions to reduce the risks to waterways. Given that the River Health Strategy is presently being developed, the benefits of any management actions within the CSHS should be assessed as part of the River Health Strategy.

7.4.3 Reduction in Salinity

Management actions that reduce the volume of recharge to the watertable will have localised benefits in terms of discharge and downstream benefits for water quality. Research has shown that there are some areas in the Corangamite region (Barwon and Moorabool Rivers) where the quality of water is showing an increasing trend in salinisation.

Drainage can have detrimental impacts on the salinity of waterways where drainage effluent is disposed of in waterways. Reuse systems can minimise the volume of drainage water and therefore can have positive impacts on water quality. Whilst reuse systems should be encouraged in most circumstances, both the private and public costs of drainage schemes need to be assessed before any actions are recommended as part of the CSHS.

7.4.4 Reduction in acidification/contamination

Land use in Australia has changed the hydrology and the biogeochemistry of the landscape, giving rise to a new set of chemicals that will be released from the land and infiltrate the country's waterways. The implications for water quality are unknown, but many believe will be as great as that of salt. Whilst best management practices are encouraging farmers to plant deep-rooted legumes like lucerne to reduce the risk of salinity, these plants cause a buildup of acid in the soil. The area of acid soils in Australia is far larger than the area affected by salt and potentially a much greater threat to agriculture and natural ecosystems.

One of the greatest threats to our water quality and coastal environment is the disturbance of acid sulfate soils (ASS) resulting in acid, aluminium and heavy metal contamination of waterways. Recent evidence also shows that rapid and devastating deoxygenation of waterways can occur when drained ASS areas are flooded, killing the fish and biota. Groundwater draw down in ASS areas has resulted in acidification and arsenic contamination, risking human health. Acid sulfate soils disturbance reduces the ecological, commercial and recreational value of our coastal waterways.

Whilst acid sulfate soils are recognised as an important threat within the Corangamite region, no management actions have been included in our assessment of the CSHS. The risks of contamination of waterways due to acid sulfate soils, or other chemicals should be assessed alongside other water quality risks as part of the River Health Strategy.

8.1 Summary of the Net Benefits of the CSHS.

The overall net benefits of the CSHS are shown in Table 8-1.

Table 8-1: Overall net benefits of the CSHS.

Production System Type	Present Value @ 8% discount over 30 years ($'000)		
	With CSHS	**Without CSHS**	**Net Present Value**
Cropping	$24,688	$14,379	$10,309
Dairy	$7,239	$4,418	$2,820
Grazing	$19,394	$8,285	$11,109
Private Forestry	$5,409	$4,123	$1,286
Total On-farm Benefits	**$56,730**	**$31,205**	**$25,525**
Landslides			$4,299
Acid Sulphate Soils	Not Quantified (see Section 7.1)		
Coastal Dune Movement	Not Quantified (see Section 7.3)		
Improved Water Quality	Not Quantified (see Section 7.4)		
Total Off-farm Benefits			**$4,299**
Total Benefits			**$29,824**

The total benefits that have been calculated for the CSHS are estimated at $29.8 million. As shown in Table 8-1, the majority of these benefits have been calculated for cropping and grazing farming systems.

8.2 Costs To Implement the CSHS

The action programs of the CSHS are set out in Section 4.2.

The costs to implement the CSHS have been quantified by the project technical group. These costs have been calculated for:

- Broadacre Grazing Farming Systems (see Table 8-2),
- Cropping Farming Systems (see Table 8-3),
- Dairy Farming Systems (see Table 8-4),
- Private Forestry (see Table 8-5), and
- Landslides (see Table 8-6).

The remaining programs (1, 2, 3 and 9) were unable to be calculated as program resource requirements have not been provided by the project technical group.

Table 8-2: Implementation costs associated with grazing land uses

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
4.1	Encourage graze and spell (rotation) based on understanding of plant and soil needs	$37,815	$425,714
4.2	Promote appropriate rate and type of nutrients/lime to match grazing demand	$37,815	$425,714
4.3	Promote the fencing of different land classes	$153,176	$1,724,417
4.4	Strategically established trees to act as windbreaks to control wind erosion	$96,065	$1,081,477
4.5	Increase the establishment of perennial pastures, with a preference for direct drilling	$151,177	$1,701,914
TOTAL		**$476,047**	**$5,359,236**

Table 8-3: Implementation costs associated with cropping land uses

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
5.1	Promote adoption of Bed Farming to reduce soil compaction and improve soil structure	$93,053	$1,047,567
5.2	Encourage appropriate lime and fertiliser application regimes to improve soil fertility and production, and reduce nutrient loss	$60,094	$676,523
5.3	Investigate alternative practices for stubble management to encourage stubble retention.	$4,578	$51,542
5.4	Promote the adoption of minimal tillage and no-till practices.	$44,775	$504,072
5.5	Support research into no-till practices.	$7,930	$89,269
TOTAL		**$210,430**	**$2,368,973**

Table 8-4: Implementation costs associated with forestry land uses

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
6.1	Encourage optimum chemical composition of soils	$60,612	$682,361
6.2	Reduce the adverse impacts of farming wet or waterlogged soils	$23,547	$265,090
6.3	Management practices to reduce losses of nutrients and sediment to waterways	$37,065	$417,271
TOTAL		**$121,225**	**$1,364,722**

Table 8-5: Implementation costs associated with dairy land uses

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
7.1	Support the implementation of the Codes of Forest Practices for Timber Production for private plantations and farm forestry through all Shire Planning Schemes.	$20,000	$225,156
7.2	Increase awareness and skills on road design, maintenance and construction to reduce sediments and nutrients entering waterways.	$4,524	$50,926
7.3	Promote farm forestry plantations in areas that benefit soil and catchment health.	$11,446	$128,855
7.4	Support the delivery of specialist technical advice in Farm Forestry to increase the implementation of best practices in site establishment and harvesting operations.	$23,836	$268,345
TOTAL		**$59,806**	**$673,281**

Table 8-6: Implementation costs associated with landslides

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
8.1	National guidelines on Landslide Risk Management	$28,737	$323,512
8.2	Implementation of uniform standards for landslide risk management	$27,334	$307,717
	Implementation of uniform standards for erosion risk management	$18,274	$205,726
	Encourage adoption of the AGS approach to landslide risk management	$7,136	$80,333
	Encourage the adoption of a responsible approach to erosion risk management	$6,313	$71,073
TOTAL		**$87,794**	**$988,361**

The present value of the total costs for implementing the CSHS have been estimated at $10.8 million (see Table 8-7). The annual equivalent cost of this present value cost is $0.88 million per year.

Table 8-7: CSHS Implementation Costs

Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
Grazing Implementation Costs	$476,047	$5,359,236
Cropping Implementation Costs	$210,430	$2,368,973
Forestry Implementation Costs	$59,806	$673,281
Dairy Implementation Costs	$121,225	$1,364,722
Landslides	$87,794	$988,361
TOTAL	**$955,301**	**$10,754,574**

8.3 Comparison of Benefits and Costs

Table 8-8 compares the net benefits with the costs of implementing the CSHS, calculated at 8 per cent over 30 years. The figures show that, overall, the proposed actions of the CSHS are economic, even without all of the off-farm benefits being quantified.

Table 8-8: Comparison of Benefits and Costs at 8% Discount

	Present Value (discounted at 8% over 30 years)
Total Benefits	$29.8 million
Total Implementation Costs	million
Overall NPV of Strategy	**million**

The results show that the CSHS is an economically feasible strategy with a net present value of around $19 million at 8 per cent discount. For more information on net benefits and costs for individual management actions, see Appendix E.

Table 8-9 compares the net benefits with the costs of implementing the CSHS, calculated at 4 per cent over 30 years. The figures show that, overall, the net present value of the CSHS increases to around $42.9 million.

Table 8-9: Comparison of Benefits and Costs at 4% Discount

	Present Value (discounted at 4% over 30 years)
Total Benefits	$58.0 million
Total Implementation Costs	$15.2 million
Overall NPV of Strategy	**$42.8 million**

Please note that because of the way that the benefits of the CSHS have been presented, that is, net of on-farm costs, it is not appropriate to present the results as a benefit cost ratio (BCR).

At the centre of the issue of catchment health are the complex inter-relationships between soil and water. Soil health issues, such as soil acidity, erosion, salinity and soil structural decline (sodicity, waterlogging, compaction) threaten agricultural production and thus jeopardise agricultural industries throughout the CCMA region. To some extent, these threats can be managed through better soil management, reducing the likelihood of these soil health threats impacting on agricultural production.

A number of strategies directed at improving catchment health already exist in the Study Area. Most of these concentrate on catchment and water management but, in part, address soil health issues. Indeed, the overall objective of CSHS is to build on existing work and develop an over-arching plan that addresses all soil health issues. The Plan would, therefore, help to ensure the long-term productivity and sustainability of land in the region while minimising the negative off-site impacts.

The methodology for the economic evaluation is based on the premise that the benefit of CSHS is the difference between the impacts on soil degradation with and without the CSHS. It is emphasised that the world 'without CSHS' would see the continued implementation of all the Corangamite regional strategies that CSHS is to link with and complement (such as, water quality and salinity). In other words, the benefit of CSHS is the *extra* improvement in soil and catchment health stemming from its implementation.

The net benefits for the implementation of CSHS were estimated as the difference between the on-farm benefits and costs of management actions to ameliorate soil degradation, and the associated off-site benefits. The net benefits of CSHS are shown in Table 9-1.

Table 9-1: Overall net benefits of the CSHS.

Production System Type	Present Value @ 8% discount over 30 years ($'000)		
	With CSHS	Without CSHS	Net Present Value
Cropping	$24,688	$14,379	$10,309
Dairy	$7,239	$4,418	$2,820
Grazing	$19,394	$8,285	$11,109
Private Forestry	$5,409	$4,123	$1,286
Total On-farm Benefits	**$56,730**	**$31,205**	**$25,525**
Landslides			$4,299
Acid Sulphate Soils	Not Quantified (see Section 7.1)		
Coastal Dune Movement	Not Quantified (see Section 7.3)		
Improved Water Quality	Not Quantified (see Section 7.4)		
Total Off-farm Benefits			**$4,299**
Total Benefits			**$29,824**

Of those off-site benefits identified, some were unable to be quantified within this evaluation of the benefits and costs of the CSHS. These included:

- Reduction in losses due to acid sulfate soils;
- Coastal dune movement; and

- Benefits from improved water quality;
  - Reduction in nutrient export
  - Reduction in sediment export
  - Reduction in salinity
  - Reduction in acidification/contamination.

Therefore, the net benefits quantified in Table 9-1, should be interpreted as a lower estimate of the overall benefits from implementing the Strategy.

The costs to implement CSHS include the costs of employing the CSHS Coordinator and Soil Health Extension Officers; community education; monitoring activities; training programs and demonstration sites; and various investigations and research programs. These costs were estimated at an annual equivalent cost of $0.96 million with a present value (8 per cent over 30 years) of $10.8 million.

The overall benefits and costs of CSHS are:

Net Benefits (on-farm)	$25.5 million
Net Benefits (off-farm)	$4.3 million
Implementation Costs	$10.8 million
Net Present Value	$19.0 million

When the benefits are compared with the costs, the results show that implementation of the CSHS has an overall net present value of $19.0 million.

It is vital to remember that a number of potential benefits could not be quantified. These relate to off-site benefits, such as, all the benefits associated with improved water quality, and all the imperfectly known off-site benefits associated with reduced soil acidity. Where these other benefits have been quantified, the attractiveness of the CSHS would be superior to that presented here.

Prioritisation of Management Actions

In assessing priorities within the CSHS, the project team have identified the impact and importance of a range of soil health issues to determine which of those issues pose the greatest risk to the region.

Whilst it is necessary to understanding the greatest soil health issues in the Corangamite region, priorities actions within the CSHS should be based on the extent with which these issues can be managed (the reduction in risk is the benefit of the action) and the costs of the actions.

For example, salinity may be a **very high** risk in the Corangamite region, but the costs to manage the risk, say by sub-surface drainage, would involve substantial economic costs and environmental impacts. For this example, the overall net benefits could be negative making it a poor investment decision. Alternatively, soil structural decline is a **high** risk in the Corangamite region, but the costs to manage the risk, say by increased use of best management practices, are small relative to the potential on-farm benefits. For this example, the overall net benefits are likely to be positive making it a good investment decision.

For most agricultural land use systems, one or a group of management actions will target a range of threats. So rather than develop costs and benefits for each soil health issue, we have assessed costs and benefits for individual management actions. Whilst we have assessed the benefits and costs of individual management actions, the net benefits shown for individual actions are not mutually exclusive and hence the individual benefits and costs can not be added. The process that was used to calculate the combined (overall) benefits and costs of the CSHS are explained in Section 6.1.1.

The benefits and costs are shown for individual management actions in Table 9-2. We have also sorted the management actions for each farming system by the overall NPV.

Table 9-2 Summary of the Net benefits to the Corangamite Region for individual management actions

Management Actions	Unit Net Private Benefits ($/ha)	NPV at 8% over 30 years (net of implementation costs)
Broadacre Grazing		
4.2 Fertiliser management	$9.00	$26,317,577
4.1 Graze and spell rotation	$11.00	$18,945,454
4.3 Land Class fencing	$4.26	$4,687,575
4.4 Trees as w ind breaks	$1.02	-$838,390
4.5 Direct drill pastures (introduce perennial pastures)	$4.27	-$1,089,410
Cropping		
5.4 Minimum Till	$27.10	$12,866,636
5.1 Bed Farming	$26.37	$6,463,701
5.2 Lime & fertility	$19.00	$6,147,868
5.3 Stubble retention	$0.00	-$51,542
Dairy		
6.3 BMP reduce nutrient export	$30.49	$4,769,436
6.2 Reverse w et soils	$19.31	$2,345,218
6.1 Fertiliser Management	$8.23	$900,859
Forestry Production		
7.1 Implement code of practice	$41.12	$5,836,383
7.2 Better road construction	$0.00	-$50,926
7.3 Forestry to improve catchment health	-$6.89	-$193,140
7.4 Support delivery of specialist technical advice	$0.00	-$268,345

The results show an interesting difference between the per unit net private benefits, and the overall NPV, which has taken into account the net private benefits, the overall adoption and the implementation costs required to achieve adoption.

For broadacre grazing, the priority management action is *4.2 fertiliser management* with a NPV of over $26 million, followed closely by the management action *4.1 graze and spell* with a NPV of close to $19 million. This differs somewhat from what the per unit private benefits would suggest, which is that the management action *4.1 graze and spell* is more cost effective.

This difference between per unit private benefits and NPV is even more pronounced when we compare costs and benefits between farming systems. Note that the greatest NPV for cropping is that associated with the management action *4.4 minimum tillage.* This management action has a per unit private benefit of over $27 per hectare, which is more than double that shown for any grazing management action for broadacre grazing. Despite this, due to differences in the extent of adoption, the NPV for *4.2 fertiliser management* is more than double that shown for *4.4 minimum tillage.*

Ultimately priorities for the region should be based on the overall benefits to the region, which is captured in the NPV estimates. This suggests that the priorities within the strategy are those shown in Table 9-3.

Table 9-3: Sorted priority actions within the CSHS.

Management Actions	Unit Net Private Benefits ($/ha)	NPV at 8% over 30 years (net of implementation costs)
4.2 Fertiliser management	$9.00	$26,317,577
4.1 Graze and spell rotation	$11.00	$18,945,454
5.4 Minimum Till	$27.10	$12,866,636
5.1 Bed Farming	$26.37	$6,463,701
5.2 Lime & fertility	$19.00	$6,147,868
7.1 Implement code of practice	$41.12	$5,836,383
6.3 BMP reduce nutrient export	$30.49	$4,769,436
4.3 Land Class fencing	$4.26	$4,687,575
6.2 Reverse wet soils	$19.31	$2,345,218
6.1 Fertiliser Management	$8.23	$900,859
7.2 Better road construction	$0.00	-$50,926
5.3 Stubble retention	$0.00	-$51,542
7.3 Forestry to improve catchment health	-$6.89	-$193,140
7.4 Support delivery of specialist technical advice	$0.00	-$268,345
4.4 Trees as wind breaks	$1.02	-$838,390
4.5 Direct drill pastures (introduce perennial pastures)	$4.27	-$1,089,410

AACM International (1995) Social and Economic Feasibility of Ameliorating Soil Acidification Land & Water Resources Research and Development Corporation

Cary J.W. and Wilkinson R.L. (1997), *Perceived Profitability and Farmers' Conservation Behaviour*, Journal of Agricultural Economics, 48(1), 13-21.

Dahlhaus Environmental Geology (2003), *Landslides and erosion: Background information for the development of the Corangamite Soil Health Strategy*, October 2003.

DPI (2003), *Acid sulfate soil hazard maps – guidelines for coastal Victoria*. CLPR Research Report No. 12, March 2003. Department of Primary Industries.

Kane, John (2003) Effluent Returns Dollars – 3 Years Of Trials Show , Dairy Extension Officer, Department of Primary Industries, Warrnambool, Victoria

MacEwan, Richard (2003), *Soil Health Strategy for Corangamite Region*. Discussion Paper.

Meat & livestock Australia (2002) SGS (Sustainable Grazing Systems) Final Report. Meat & livestock Australia

Meat & livestock Australia (2002) The SGS National Experiment: Summary of findings from Sites and Themes. Meat & livestock Australia

Read Sturgess and Associates (1998), *Benefits and Costs from Reducing Frequency of Algal Blooms in Corangamite Region*.

Read Sturgess and Associates (1996), *Tuckean Swamp Economic Study: an evaluation of options for managing problems associated with flooding, drainage and acid sulfate soils*. Consultancy undertaken for the Tuckean Swamp Management Committee.

Rendell McGuckian, John Marriot, Mike Stevens & Associates (1999). Business Analysis for Wool Growers, FAST Project. Department of Natural Resources.

Moran, C.J. (1998), "Land degradation processes and Water quality effects: decline in soil structure", Farming Action: Catchment Reaction CSIRO Publishing, Collingwood, Victoria.

Rob Rendell, Phil O'Callaghan & Neil Clark (1996), *Families, Farming & The Future FAST PROJECT Business performance indicators for farming systems in the Wimmera and Mallee of Victoria.* Report prepared for Agriculture Victoria, GRDC, RIRDC, National Landcare Program and the National Australia Bank

Sammut, Jesmond (2000), *An introduction to acid sulfate soils*, Booklet prepared for Environment Australia and AFFA, June 2000.

Sinden J.A. and King D. (1990), *Adoption of soil conservation measures in Manilla Shire, New South Wales*, Review of Marketing and Agricultural Economics 58(2,3) pp179-192.

UNEWQS (1998), *Upper North East Water Quality Strategy*.

URS (2003), *Agriculture and Forestry in the Corangamite Region*. Final report prepared for the Department of Primary Industries, January 2003..

URS Forestry (2003), *Socio-Economic Study of the Forest Industries in Central Victoria*, Consultancy report prepared for DSE and CVFPC.

BENEFIT-COST ANALYSIS

Benefit-cost analysis is a conceptual framework for the evaluation of programs and projects in the public sector. It differs from financial analysis conducted by firms in the private sector in that it accounts for gains (benefits) and sacrifices (costs) irrespective of to whom they accrue. The following are some key concepts and calculations involved in benefit-cost analysis.

CONCEPTS AND CALCULATIONS

Present Value (PV) is the equivalent value today of a future benefit or cost. It is calculated as the value of a future sum or sums discounted at a given discount rate. The present is usually referred to as year zero. The present value of a sum of money S (benefit or cost) which is to be received in year t is calculated as:

$$PV = S_t \, [1 / (1 + i)^t] \quad (1)$$

Where i is the discount rate specified as a decimal fraction (for example, 0.08 for 8 per cent). If \$100 is to be received as a benefit in year 10, the present value of that benefit at a discount rate of 8 per cent is \$46.32 (that is, $100/(1.08)^{10}$). Thus, \$46.32 now is equivalent to \$100 in year 10. This is because \$46.32 invested now at 8 per cent would grow to \$100 in year 10. If the discount rate were 4 per cent, \$100 in year 10 has a present value of \$67.56.

The present value of stream of benefits (costs) in years 1 to T is the sum of the present values of the amounts received (paid) in each year.

$$PV = S_0 + S_1[1 / (1 + i)] \ldots + \ldots S_t[1 / (1 + I)^t] \ldots + \ldots S_T[1 / (1 + I)^T] \quad (2)$$

Net Present Value (NPV) is the present value of all benefits minus the present value of all costs. This is equivalent to the sum of the flow of annual net benefits, each of which is expressed as a present value.

An annuity is a series of equal annual sums of money. The present value of a fixed term annuity ‘a’ that ends in year t (say, year 30) is calculated as:

$$PV = a \, [(1 + i)^t – 1] / [i(1 + i)^t] \quad (3)$$

The present value of a perpetual annuity is calculated as:

$$PV = a / i \quad (4)$$

The annuity or annualised amount equivalent to a given PV is obtained by making ‘a’ the subject in the appropriate formula.

The discount rate is a complicated phenomenon that can be thought of as the rate of exchange between value today and value in the future. We do not delve into the issues that help to determine the appropriate rate - the interested reader is referred to the references at the end of this Appendix.

It is recommended that the rate used in the analysis be regarded as the ‘real’ or inflation-free discount rate. The real rate is approximately equal to the nominal rate minus the rate of inflation. Use of a real rate of discount means that year zero values of benefits and costs can be used throughout the analysis. If the nominal rate were used, benefits and costs would have to be measured in the dollar values in the year they accrue.

As the above formulae show, PV is inversely related to the rate of discount, therefore, a project may be acceptable at a low discount rate but not at a higher rate. As illustrated by Investments A and B below, this can occur if the project yields benefits in the distant future. It is prudent, therefore, to test the sensitivity of the results of a benefit-cost analysis to this key parameter.

Investment A (cost = $550 in year 0, benefit = $1,200 in year 10)

Discount rate (%)	PV benefit ($)	PV cost ($)	NPV ($)
4	810	550	260
6	670	550	120
8	556	550	6

Investment B (cost = $550 in year 0, benefit = $1,500 in year 15)

Discount rate (%)	PV benefit ($)	PV cost ($)	NPV ($)
4	833	550	283
6	626	550	76
8	473	550	-77

Conclusions:

- at a discount rate of 4 per cent, both investments are sound but B would be preferred;
- at a discount rate of 6 per cent, both investments are sound but A would be preferred; and
- at a discount rate of 8 per cent, only Investment A is profitable and would be preferred. Investment B is not profitable at this discount rate.

It should be noted that these sorts of results are not uncommon. The example shows the importance of demonstrating to the decision makers the sensitivity of the results to the discount rate. Their funding decisions will be influenced by the beliefs about the appropriate rate at the time.

DECISION RULES IN BENEFIT-COST ANALYSIS

(i) The NPV rule.

The prime decision rule in benefit-cost analysis is that a program or project should, subject to budget constraints, be accepted if the PV of benefits exceeds the PV of its costs, that is, the program's NPV is greater than zero.

(ii) The Benefit:Cost Ratio (BCR) rule

The BCR of a program is calculated by dividing the PV benefits by the PV of its costs:

$$BCR = PV\ benefits / PV\ costs$$

A program with a BCR greater than one is acceptable because the PV of benefits exceeds the PV of costs. A benefit:cost ratio of 1.3 indicates that $1.30 PV of benefit is received for each $1.00 PV of cost.

The BCR is a useful adjunct to the NPV but it should not be used as the sole decision rule because it may give an incorrect ranking if the projects differ in size.

REFERENCES

The following texts on benefit-cost analysis are recommended for the interested reader.

Sinden J.A. and Thampapillai D.J. (1995), *Introduction to benefit-cost analysis*, Longmans Australia Limited.

Department of Finance (1991), *Handbook of cost-benefit analysis*, Australian Government Publishing Service.

COST SHARING PRINCIPLES

Cost-sharing negotiations should proceed only after a proposed management project has passed the benefit-cost test. There is little point arguing about sharing of costs for inefficient projects. The benefit-cost methodology for ranking projects essentially tells us whether or not a particular project is likely to increase community welfare. This is the critical first step and should not be overtaken by undue emphasis on how the project should be paid for, and by whom. The benefit-cost analysis will also assist in identifying the stakeholders between whom costs should be shared.

Three sources of funding can be considered:

1. private entities or local agencies whose actions are causing the degradation that is giving rise to the need for the implementation of the plan (i.e. the 'polluters pay');

2. private entities or local agencies who would benefit from the implementation of the plan (i.e. the 'beneficiaries pay'); and

3. Government.

POLLUTERS PAY

It has been a long-standing code of human conduct that if you make a mess you clean it up. This notion has been enshrined in the 'polluter-pays' principle for environmental protection. Demanding that polluters pay is often society's policy of first choice because it is regarded as being the fairest and most equitable policy. It is also the most efficient policy when the principle can be applied to stop pollution before it occurs, or to control it within acceptable limits.

Therefore, where the polluter-pays principle is appropriate and the polluters can be identified and their pollution measured, monitored and levied, it is sensible that that polluter-pays principle should take precedence over the beneficiary-pays principle for sharing the funding of management measures. To do otherwise runs the risk that the pollution may continue unabated.

The principle may be made operational in a variety of ways, including:

- a tax to discourage pollution;
- requirements for those causing damage to pay for fixing it up; or
- requirements to pay compensation to affected parties after causing a polluting event.

The polluter-pays principle, therefore, is a principle, which provides an economic disincentive to pollute (Read 1984 and OECD 1989). While full adherence to the polluter-pays principle would require that the polluters bear the full cost of pollution control measures, a degree of flexibility has arisen in application of the principle. In some circumstances, if the cost to the polluter of full adherence is very high, 'compatibility' with the principle may be all that is required.

There are difficulties in applying the polluter-pays principle, which concern the identification of the polluters. It may be readily applicable when the source of pollution can be traced to a particular entity (so-called point-source pollution). It is much more difficult to apply when there are high costs of identifying the polluters and monitoring the damage they cause. This is particularly the case for 'non-point' pollution arising from broadacre activities that may be damaging soil health. However, the scope for converting a non-point source problem into a point source problem by dealing with an agricultural community on a catchment basis should not be ignored. For example, farmers in the sub-catchment might be held collectively responsible for meeting standards of practice and if those standards are not met pollution levies may be charged against them. This may encourage individuals to monitor each other's behaviour so that serious offenders are isolated.

However, a major consideration against using the polluter-pays principle is the likelihood that soil degradation is, in part, the result of past activity which was sanctioned by governments. Clearly, there is no way that past generations of farmers or governments can be brought to account and even if it were possible it would not solve the problem. With improved present knowledge about the processes involved, the practical action is to wipe the slate clean and set about managing for the future. In such situations there is probably no alternative other than for the present beneficiaries to pay for the improvements they will receive.

In the future, however, as progress is made convincing farmers that they have a 'duty of care' rather than a right to do what they wish, the government may be in a position to provide clear guidelines as to which practices are considered acceptable, and any subsequent adoption of 'poor' practices could be viewed as damaging. Those responsible could fairly be asked to cease those practices or to compensate those suffering the impacts.

BENEFICIARIES PAY

The main convention by which commercial affairs are conducted is that the 'user' or 'beneficiary' of some service pays for that service. By paying prices that reflect the social value of these goods and services, an economically efficient allocation of resources can be ensured. Governments and public authorities have come to realise that it is important for the efficient use of scarce resources that the services provided by public authorities also be paid for by the users or beneficiaries of those services. Thus, the beneficiary-pays principle has been adopted by many authorities for determining who should meet the costs of the works undertaken as part of land and water planning.

Marsden (1996) postulated 'strong' and 'weak' versions of the beneficiary-pays principle, which the MDBC (1996) termed the 'user-pays' principle and the 'beneficiary-compensates' principle respectively.

Strong beneficiary-pays principle ('user pays')

Anyone who derives a direct benefit from management actions should contribute to the cost of the actions in direct proportion to their share of the total benefits.

When the bulk of benefits are private benefits and can be valued in markets, application of the user-pays principle presents few problems. The following steps are required to put the 'strong' version of the beneficiary-pays principle into effect.

- Identify all the beneficiaries of the management proposal.
- Measure the benefits they receive.
- Charge the beneficiaries the full cost in proportion to the benefits received.

If all the benefits were priced in competitive markets this process would help society pursue the goal of an efficient allocation of resources.

Unfortunately, this simple mechanistic process can seldom, if ever, be put in place because, amongst other problems, not all the benefits are priced in markets. Suppose, for example, that an action produces a mix of public benefits and private benefits. If the dollar value of public benefits cannot be determined, the proportion of total benefits accruing as public and private goods cannot be determined. Therefore, in such a situation, the strong version of the beneficiary-pays principle cannot be implemented. Thus:

> *we must recognise the dilemma that the principle of distributing costs in proportion to the share of the benefits is least feasible in precisely those cases where the principle is most likely to be sought to be applied (Marsden 1996 p.9).*

The precision and simplicity of the strong version may encourage the valuing of unpriced benefits using stated preference methods, such as contingent valuation or choice modeling. However, despite the considerable advances that have been made in these techniques in recent years, they remain controversial and difficult to apply. They are also sparsely applied, so that the probability that suitable valuations will be available for any given problem is very low.

Another way of coping with this situation is to propose a mild version of the beneficiary-pays principle – the beneficiary-compensates principle.

Weak beneficiary-pays principle ('beneficiary compensates')

All identified beneficiaries meet some portion of the costs and together the beneficiaries cover all the costs associated with the works or activity[1].

This principle has tended to be applied where a public conservation good is supplied jointly with a private good (Marsden 1996, Marshall 1998). For example, protection of remnant native vegetation provides private benefits to a farmer in the form of shelter for livestock and public benefits, such as, the preservation of habitat for native birds and animals. Under the beneficiary-

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[1] Earlier, the OECD (1989) had put forward a similar view when it noted that paying the full cost for the quantity of benefit received may not be required; that is, 'compatibility' with the beneficiary-pays principle may be required rather than full adherence. For example, in some circumstances where beneficiaries do not have the ability to pay, the notion of compatibility may be invoked. The government or authority in this situation must exercise extreme caution, however, lest an inappropriate subsidy results. The share of the full cost paid and the proportionality between the benefits received and the payment might be used to assess compatibility.

compensates principle, people who are beneficiaries of the conservation good pay for the additional costs to the landholders of maintaining that good.

The weak version of the beneficiary-pays principle reflects a particular view of fairness that is not based on any rigorous theory. As Musgrave (1996) points out, other positions are possible including one (as a variant of the weak version):

> *which would restrict the government's share of costs to that which is sufficient to induce the private beneficiaries to produce the desired level of public benefits. While appearing to discriminate against the private beneficiaries, this helps to maximise the spread of the government's budget and be fair to the taxpayer. In fact, an array of positions exist and selection between them would seem to call for some form of negotiation.*

This aspect of the beneficiary-compensates principle is a key issue when attempting to minimise government's payment to achieve a result and be fair to the taxpayer. In the extreme, if the action is profitable to the private beneficiaries, no government share would be required unless government wished to increase the rate of adoption.

GOVERNMENT PAYS

Government contributions to the funding of on-ground works can be justified in situations where there would be too little investment in preventing soil degradation it were left entirely to the free market. The reasons for this proposition are:

- the polluters are unaware of the effects of their actions on other parties ('externalities');
- enjoyment of the benefits cannot be restricted to a particular group of private entities (that is, the benefits represent 'public goods'); and
- the costs of collecting contributions from each private beneficiary or polluter would be too large relative to the contributions required from those entities (that is, the 'transaction costs' are excessive when collecting contributions from the private entities). For example, the off-site benefits to recreationists and future generations.

REFERENCES

Marsden, J. (1996), "Cost-Sharing – the Murray Plains", in Price, P. (ed), Sustainable Management of Natural Resources: Who Benefits and Who Pays, Occasional Paper No. 01/96, Land and Water Research and Development Corporation, Canberra.

Marshall, G.R. (1998), "Economics of Cost-Sharing for Agri-Environmental Conservation", paper presented to the 42nd Annual Conference of the Australian Agricultural and Resource Economics Society, University of New England, Armidale, 19-21 January.

OECD, (1989), Economic Instruments for Environmental Protection, OECD, Paris.

Read, Michael and Associates (1984), Financing salinity control in Victoria, Discussion Paper prepared for Salinity Committee of the Victorian Parliament, Melbourne.

ADOPTION RATES FOR AGRICULTURAL PRODUCTION SYSTEMS

It is important to consider the main incentives and barriers to adoption of new farming practices and how this applies to the programs within CSHS.

In RMCG's experience adoption of practices tends to be faster for those practices that:

- Reduce labour requirements
- Have a low capital requirement
- Provide a margin of $2 income for every $1 in operating expenses
- Create a readily saleable asset

In the case of many of the actions proposed under CSHS the outcomes can be more labour, more capital, uncertain margins and not necessarily the creation of a readily saleable asset.

The main barriers are seen to be:

- Financing the capital required to convert to improved practices and finance an increase in stocking rate at the same time
- Financing of practices that provide minimal on farm benefits, such as reducing nutrient runoff from dairy farms
- The large change in labour, machinery and skill requirements in changing from a grazing system to a bed farming system
- Loss of feed when converting existing paddocks when the need is to be increasing stocking rates to utilise the extra feed after the perennial pastures are established
- Inherently higher risk position of adopting higher stocking rates both from a drought perspective (need to feed or de-stock earlier)and debt load perspective
- Many of the recommended on farm practices have costs which are constant over time while the benefits are very variable over time. In order minimise risk land managers often avoid practices that have benefits that are very variable over time.

The fact that current adoption rates of the practices are low (42% for cropping, 21% for dairy and 18% for grazing) infers that there are significant barriers to adoption.

Therefore, the adoption rates for the CSHS must be set at realistically slow levels.

Appendix D

KEY ASSUMPTIONS USED IN THE BENEFIT COST ANALYSIS

GENERAL ASSUMPTIONS

Discount Rate	A ‘real’ discount rate (based on inflation-free interest rates) of 8 per cent was used
Existing Farm Assets	Exiting farm assets assumed to be adequate for the implementation of actions unless otherwise costed
Total Agricultural Area	The total agricultural area will remain unchanged over the investigation period
Production Systems	Costs, benefits and adoption rates have been determined for each production system, Variations within production systems have not been incorporated to this study

ON-FARM ASSUMPTIONS

Cropping

Growth in Area	Growth in area of cropping will be 1% per year without strategy
Combined Practices	On farm practices will be adopted as a combination of practices
Gross Income	Annual income per hectare is $900 based on 5t/ha/year of wheat at $180/t
Property Size	Assumed property size of 250ha

Dairy

Growth in Area	Growth in area of dairy will be 1.3% per year without strategy
Combined Practices	On farm practices will be adopted as a combination of practices
Gross Income	Annual income per hectare is $1200 based on 1.5headt/ha at $800/head/year
On farm Management	Practices will increase management costs and reduce flexibility
Property Size	Assumed property size of 200ha
Additional Stock	Costs of additional stock to increase production have not been attributed to costs for on-farm practices

Grazing

Growth in Area	As cropping and dairy areas grow, grazing area will decrease
Combined Practices	On farm practices will be adopted as a combination of practices
Gross Income	Annual income per hectare is $240 based on 12dse//ha at $20/dse/year
On farm Management	Practices will increase management costs and reduce flexibility

Land class fencing	Land class fencing is assumed to require 1km of fencing per 100ha
Property Size	Assumed property size of 300ha
Additional Stock	Costs of additional stock to increase production have not been attributed to costs for on-farm practices

Farm Forestry

General

Total Area of Private Forestry	51,350 hectares (comprising 46,280ha of private plantation forestry and 5,070ha of private farm forestry) – from URS Forestry (2003), *Socio-Economic Study of the Forest Industries in Central Victoria*, prepared for DSE and CVFPC
Species mix	60 per cent Softwood (Radiata Pine), 40 per cent Hardwood (Blue Gum)
Rotation Length	Softwood 28 years, Hardwood 20 years
Current Industry Expansion	Current annual growth in private plantations in the Region include 260ha/yr for softwood and 500ha/yr for hardwood
Annual equivalent of returns from forestry	Based on a combination of softwood and hardwood rotations, average returns of $140 per hectare per year were assumed for all species

Marginal sites

Plantation establishment costs	$1,200 per hectare
Change in establishment costs	Establishing plantations on marginal sites to increase establishment costs by 50 per cent (or $600 per ha)
Sheep Carrying Capacity	1.4DSE/ha/100mm rainfall - based in low Victoria average sheep stocking rate
Average Annual Rainfall	700 mm
Sheep Gross Margin	$12 per DSE – based on low Victoria average gross income of $20 per DSE and variable costs of $8 per DSE
Current Adoption	10 per cent of total area planted
Current adoption rate (with no intervention)	0.1 per cent per year
Expected adoption (with CSHS)	1.0 per cent per year

Implement Code of Forest Practices

Management practices encouraged by action	Ground preparation (ripping and mounding) and road design, construction and maintenance
Site preparation	Average site preparation costs assumed to be $190 per hectare
	Contour ripping and mounding to increase site preparation costs by 25 per cent
	15 per cent increase in production value due to improved site preparation
Road design and construction	Additional cost of adhering to Code of Forest Practices, which includes improved road design and construction is assumed at $100 per hectare planted
Road maintenance cost	Current average annual road maintenance cost of $100 per hectare
Change in Road maintenance cost	25 per cent decrease in road maintenance costs
Future establishment costs	Adherence to COFP assumed to reduce future establishment costs by 10 per cent (currently assumed at $1,200 per hectare)
Current Adoption	30 per cent of total planted area
Current adoption rate (with no intervention)	1.0 per cent per year
Expected adoption (with CSHS)	5.6 per cent per year

Develop Discussion Groups

Effect on implementation of land practices	Assumed to increase the adoption of other CSHS actions by an additional 0.5 per cent

OFF-FARM ASSUMPTIONS

Nutrients

Source of Nutrients	50 per cent of nutrients in the Corangamite are sourced from agricultural land
Manageability	Less than 40 per cent of nutrients from agricultural land is manageable from on-farm management actions.

Appendix D

Landslides

Magnitude of the Consequences	The value of damages to Municipal infrastructure for a range of landslides that occurred over the past 50 years have been used to estimate the magnitude of various levels of consequence
Likelihood of Landslides occurring	Strategy will reduce likelihood of various consequences associated with landslides by half
Realisation of benefits	Benefits are progressively realised over 10 years

Appendix E

SUMMARY OF PRIVATE NET BENEFITS AND COSTS AND IMPLEMENTATION COSTS (at 8 per cent discount)

Management Actions	PV of Net Benefits	PV of Net Costs	PV of Implementation Costs	NPV
Broadacre Grazing				
4.1 Graze and spell rotation	$63,396,550	$44,025,382	$425,714	$18,945,454
4.2 Fertiliser management	$35,657,721	$8,914,430	$425,714	$26,317,577
4.3 Land Class fencing	$25,283,276	$18,871,285	$1,724,417	$4,687,575
4.4 Trees as wind breaks	$1,139,452	$896,365	$1,081,477	-$838,390
4.5 Direct drill pastures (introduce perennial pastures)	$3,444,350	$2,831,846	$1,701,914	-$1,089,410
Combined	***$35,186,336***	***$24,076,895***	***$5,359,236***	***$5,750,204***
Cropping				
5.1 Bed Farming	$25,635,201	$18,123,934	$1,047,567	$6,463,701
5.2 Lime & fertility	$16,163,033	$9,338,641	$676,523	$6,147,868
5.3 Stubble retention			$51,542	-$51,542
5.4 Minimum Till	$13,410,308	-$49,668	$593,341	$12,866,636
Combined	***$23,043,873***	***$12,735,219***	***$2,368,973***	***$7,939,681***
Dairy				
6.1 Fertiliser Management	$15,117,105	$13,533,885	$682,361	$900,859
6.2 Reverse wet soils	$16,098,992	$13,488,685	$265,090	$2,345,218
6.3 BMP reduce nutrient export	$10,870,599	$5,683,891	$417,271	$4,769,436
Combined	***$13,123,458***	***$10,303,044***	***$1,364,722***	***$1,455,692***
Forestry Production				
7.1 Implement code of practice	$7,006,861	$945,323	$225,156	$5,836,383
7.2 Better road construction			$50,926	-$50,926
7.3 Forestry to improve catchment health	$419,728	$484,013	$128,855	-$193,140
7.4 Support delivery of specialist technical advice			$268,345	-$268,345
Combined	***$3,476,911***	***$2,190,862***	***$673,281***	***$612,768***
Non Agriculture				
Municiple Costs				
8.1 National guidelines on Landslide Risk Management			$323,512	-$323,512
8.2 Implementation of uniform standards for landslide risk management			$307,717	-$307,717
8.2 Implementation of uniform standards for erosion risk management			$205,726	-$205,726
8.2 Encourage adoption of the AGS approach to landslide risk management			$80,333	-$80,333
8.2 Encourage the adoption of a responsible approach to erosion risk management	$4,299,016		$71,073	$4,227,943
Combined	***$4,299,016***		***$988,361***	***$3,310,655***
Total	**$79,129,594**	**$49,306,020**	**$10,754,574**	**$19,069,000**