5. Results

5.1 Introduction

The purpose of this chapter is to outline the results of this study, the aim of which was to compare the priced benefits and costs of adopting the catchment management plan against current landuse, using both deterministic and stochastic analysis. The overall framework used in this study is the safe minimum standard game theory approach, with estimation of net present values using discounted cash flow techniques.

A spreadsheet model was developed to undertake the deterministic cash flow analysis, combined with a risk analysis program (@Risk) which used Monte Carlo simulations to undertake the stochastic analysis. The results are presented in terms of the expected net present values and cumulative probability distributions of net present values. The minimax decision criterion is then used to compare estimates of the cost of the catchment management plan against the unpriced benefits of avoiding irreversible loss. Finally, an analysis was conducted on the spreadsheet model developed to determine whether the results are sensitive to changes in the key variables and parameters used in the model.

5.2 Discounted Cash Flow Analysis

Discounted cash flow analysis was used to calculate the net present values for each strategy. The discounted cash flow analysis, as the name suggests, provides an indication of the cash flowing into and out of the project over the life of the investment. A summary of the results of the discounted cash flow analysis for selected years is presented in Table 5.1. All figure are presented in 1997 dollar terms for a social discount rate of five per cent.

The net present values of the current land use and the catchment management plan are estimated to be $13.469 and $13.659 million, respectively (see Appendix G). The net benefit of implementing the catchment management plan therefore is the difference between the two, which is $190,136. Implementing the catchment management plan was also found to generate an internal rate of return of 10.27 per cent and a cost-benefit ratio of 1.01. Thus, the project is economically viable.

The total gross margin of agricultural production under the two strategies for selected years is presented in Table 5.1 and for the entire study period is presented in Figure 5.1. It can be concluded that in the first few years there is little difference between the total agricultural gross margins between the two strategies. The initial difference in the total gross margin of agricultural production under the catchment management plan is due to the assumed yield penalties and establishment costs. However, after year eight, the flow of benefits from implementing the catchment management plan begin to take effect with a resulting increase in the net gross margin of agricultural production.

Under current landuse however, the gross margin of agricultural production from the catchment gradually declines as the effects of rising groundwater and the spread of salinity begin to take effect. By the end of the study period salinity is estimated to cost approximately $80,913 annually. The maximum cumulative loss (change in agricultural gross margin and the change in capital) between the two strategies is $168,845 which occurs in year seven. This translates to a loss of approximately $103 per productive hectare. By year eight however, the cumulative loss gradually starts to diminish as the effects of the catchment management plan begin to take effect and is positive by year 15, whereby the benefits of implementing the catchment management plan outweigh the costs (see Figure 5.1).

Table 5.1 Summary of the Results between the two Strategies

	Total Gross margin for the Catchment ($)		
Year	Current	CMP	Net Benefit
5	885,094	874,921	(10,173)
10	879,538	889,350	9,812
15	873,302	911,098	39,132
20	866,304	911,098	44,794
25	858,450	911,098	52,647
30	849,637	911,098	61,461

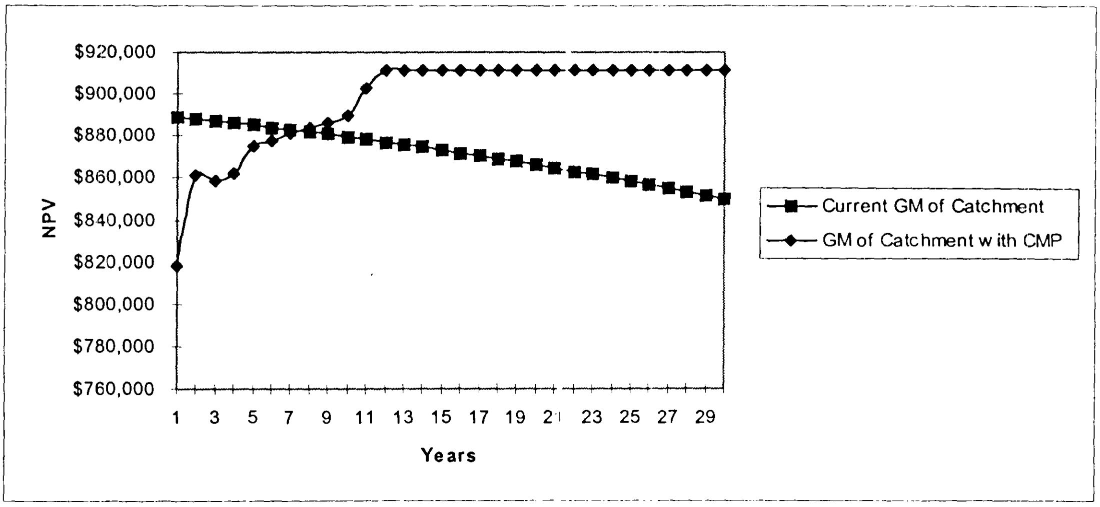


Figure 5.1 Annual Gross Margins for the Gerangamete Catchment Under The Two Strategies

5.3 Risk Analysis

In the preceding discussion the results of the deterministic analysis were outlined. The comparison was also analysed stochastically using risk analysis where probability distributions were used to describe key variables. The results of the stochastic analysis are presented below.

5.3.1 Comparison of Strategies

The net present values, and the cumualtive probability of the net present values obtained for the two strategies using risk analysis, are presented in Table 5.2 and Figure 5.2 respectively. The cumulative distribution functions describe the probability distributions for the net present values. In Figure 5.2, the vertical axis shows the cumulative probability of obtaining the net present values shown on the horizontal axis.

If the stochastic dominance criterion is applied to results of the risk analysis, it is evident that the cumulative probability curve of the catchment management plan dominates the current strategy for all cumulative probabilities, and is therefore first degree stochastic dominant over the current strategy.

Table 5.2 Net Present Value of the Two Strategies ($m)

Land Use Strategy	Mean	Standard Deviation	Range
Current Land Use	13.46	0.68	11.47 to 15.25
CMP	13.66	0.62	11.82 to 15.29

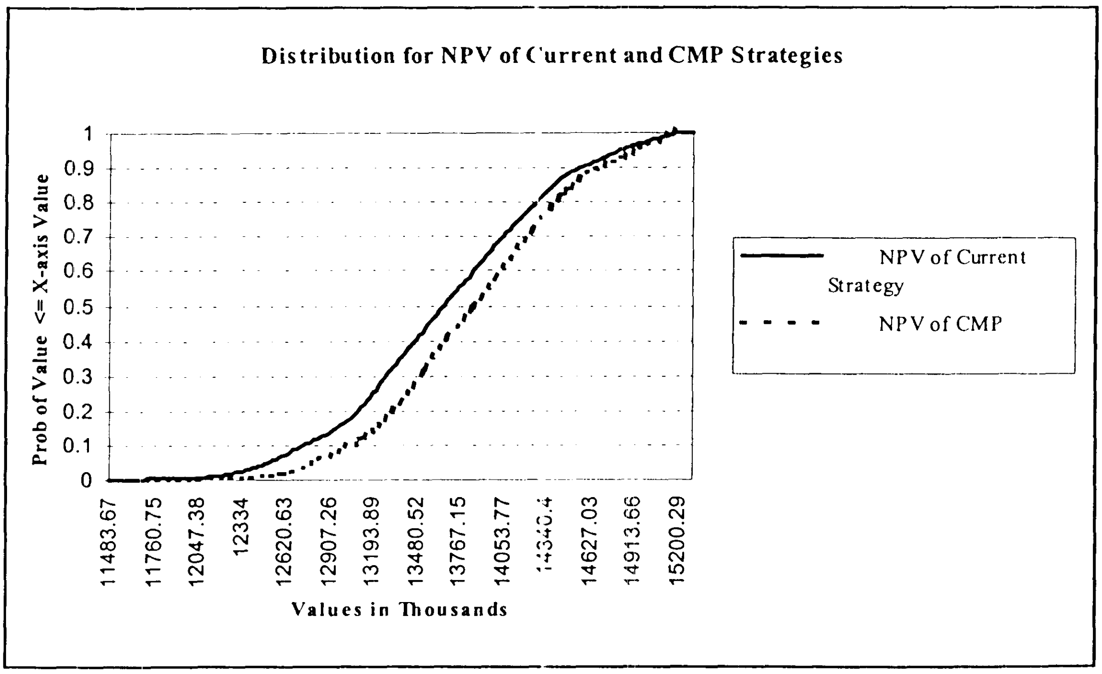


Figure 5.2 Cumulative Value of Current and CMP Strategies

5.3.2 Difference between Current and the Catchment Management Plan Strategies

In this study the maximum cumulative loss was likened to the insurance premium required to maintain the safe minimum standard. The maximum cumulative loss is simply the annual cumulative difference between the two strategies at its maximum.

The deterministic analysis estimated the net present value of undertaking the catchment management plan to be $13.65 million and stochastically to be $13.46 million. Before the benefits of the catchment management plan are realised however, there are likely to be costs. In this study the maximum cumulative loss of implementing the catchment management plan was found to be $168,845 for the deterministic analysis which occured at the end of year seven, and $168,902 for the stochastic analysis which also occured at the end of year seven (see Table 5.3). The cumulative probability function for the maximum loss in year seven is illustrated in Figure 5.3. It is evident from Figure 5.3, that while the maximum cumulative loss of the catchment management plan will be $216,643, there is only a five per cent probability that the net present value of the catchment management plan will exceed $199,717. Thus, there is a ninety per cent probability that the net present value of the catchment management plan lies between $138,170 and $199,717.

Table 5.3 Annual Cumulative Difference Between the Two Strategies ($)

Year	Mean	Std	Range
7	-168, 902	18, 441	-216, 643 to -114, 729

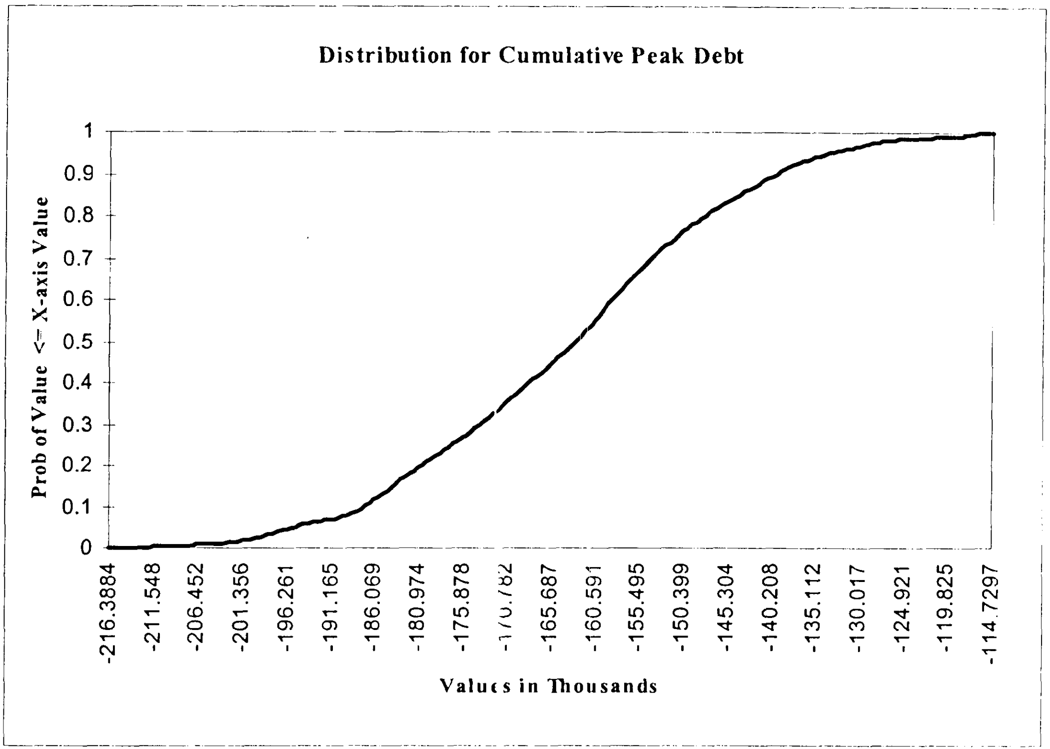


Figure 5.3 Cumulative Probability for Peak Debt (Year 7)

5.4 Sensitivity Analysis

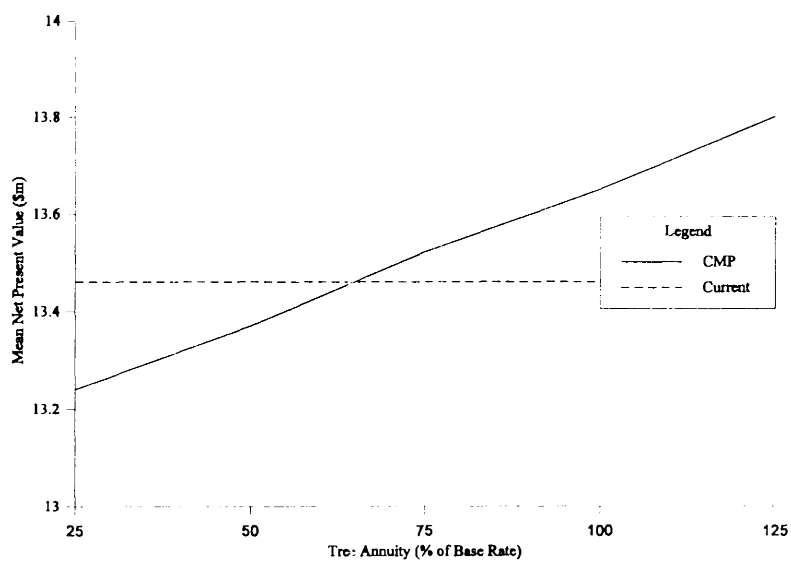
In the analysis undertaken in Section 5.3, a number of assumptions were made regarding the values of selected parameters. The results that were derived from this analysis are dependent upon a number of parameters used in the model. In this section sensitivity analysis is undertaken on dependent variables to gauge the effects their changes will have on the results and final outcome.

Sensitivity tests were not undertaken on the deterministic discounted cash flow analysis, but instead were tested stochastically to estimate break-even (or crossover) values. This was done by keeping the distributions the same, while lowering or raising the means and re-running the stochastic analysis. The key variables considered unique to the catchment management plan were research and extension costs, and the proposed salinity control programs notably tree establishment and pasture improvement. The key variables unique to the current strategy are the effects of lost production that may be caused by dryland salinity.

5.4.1 Sensitivity to Tree Benefits

The estimation of tree benefit annuities can vary enormously with the physical conditions of the site and market supply and demand, and consequently could be considered as critical variables which could alter the ranking between the strategies. Annuities for tree benefits were varied from 25 to 125 per cent of the original estimates for mode, minimum and maximum values. The mean net present value for each strategy are displayed as Figure 5.4. The net present value for the current strategy is unchanged at $13.46 million, but as the annuities decrease the net present value for the catchment management plan declines. The break-even value where the net present value of the current strategy equals that for the catchment management plan is reached when the annuity of tree benefits decreases by 70 per cent of the original estimate.

Figure 5.4 ***Effect of Net Benefit of Trees on the Mean NPV***



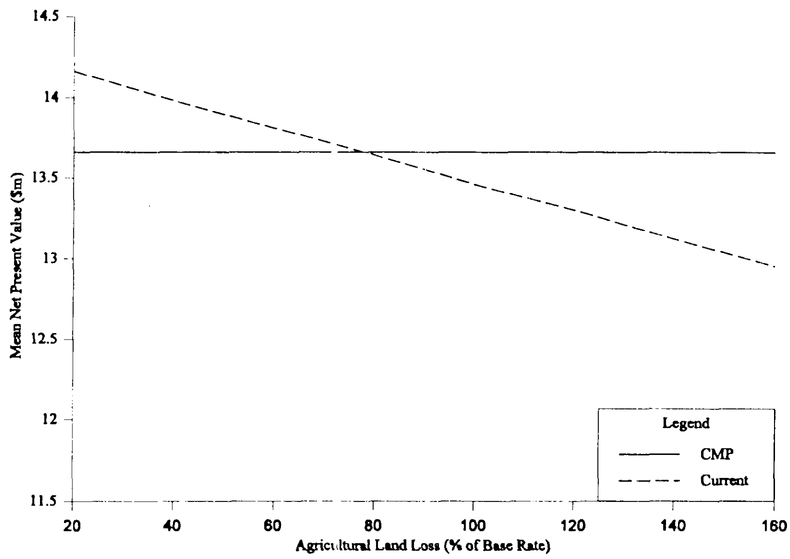
5.4.2 Sensitivity to Agricultural Land Loss and Effects of Salinity

The main effect of rising groundwater and salinity is its impact on agricultural production by way of reduced yields and, under more extreme conditions, by preventing plant growth. When this occurs, the value of agricultural production and the value of the land in the affected area declines, gradually eroding the farm asset value. Under the current strategy (no intervention), rising groundwater and the spread of dryland salinity are expected to reduce agricultural production and subsequently farm asset value. The original estimates of salt affected land will therefore be critical to the net present value calculated for the current strategy. To observe the effect of changes in the original estimates of salinity on net present value, the rate of land estimated to be lost to salinity was varied from zero to 160 per cent of the original estimates for the mode, minimum and maximum values.

As anticipated, increased estimates of the land affected by salinity will only serve to increase the relative benefits attached to the recommended CMP. Reductions in the estimates however, will impact on the ranking between the two strategies. The mean net present values for each strategy are displayed as Figure 5.5. The catchment management plan strategy is not affected by salinity so the net present value for that strategy is constant at $13.66 million. It is evident from Figure 5.5, that as the effect of salinity increases, the net present value for the current strategy is reduced, which is what one would expect to happen.

The break-even value where the net present value of the current strategy equals that for the catchment management plan is reached when the rate of land loss is reduced to near 70 per cent of the original estimate. The data used to model the spread of salinity was the best available for the catchment. If the original estimates of salinization and its spread were incorrect it could affect the ranking of the strategies. The net present value for the current strategy is therefore considered sensitive to changes in the rate of land lost from agricultural production. Thus there may be a need to substantiate the hydrological predictions and to obtain some estimate of probability for the reduction rate of 30 per cent of the original estimates.

Figure 5.5 ***Effect of Increased Rate of Salinisation and Agricultural Land Loss***

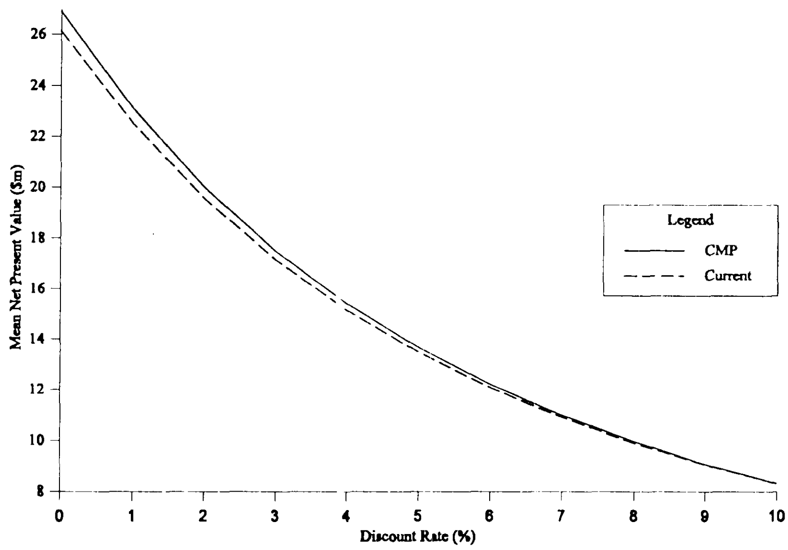


5.4.3 Effect of Social Discount Rate

As outlined in Section 3.4 and illustrated in Appendix D, the social discount rate can have a major impact on the net present value. For this study, a social discount of five per cent was used. This rate however was varied to guage its impact on the net present value and ranking of the two strategies. The results of this sensitivity analysis are presented in Figure 5.6.

Results indicate that the mean net present value for the catchment management plan is higher than for the current strategy over the discount rates ranging from zero to ten per cent. Beyond ten per cent however, the net present value of the current strategy is higher than that for the catchment management plan. The result is therefore not sensitive to discount rate over a range accepted for social cost-benefit analysis.

Figure 5.6 ***Effect of Discount Rates***



5.5 The Payoff Matrix

The minimax decision matrix which describes the Gerangamete catchment problem developed in Chapter 3 promotes the use of the decision criterion of the safe minimum standard of resource use. Using this framework (the results of which are presented in Table 5.4), the maximum loss that can occur with the catchment management plan strategy with either state of nature is C - B^*(unpriced), while the maximum loss under current land use practices is equal to B(priced) + B(unpriced). Under the decision rule posed for the safe minimum standard, the catchment management plan should be selected, provided the cost of doing so is not unreasonably large. To determine if the costs are unreasonably large, the net value of priced costs and benefits, C , are weighed subjectively against the unpriced benefits B^*(unpriced) of avoiding irreversible losses.

The expected value, from the deterministic analysis, of priced costs C minus the priced benefits (B^*unpriced) between the catchment management plan and current practices was $190,136 (see Appendix G). The main assumption employed to achieve this result is that the catchment management plan will prevent the spread of salinity and associated agricultural productivity loss. The stochastic estimate of the mean difference between the catchment management plan and current landuse was $189,657, reflecting a net benefit from implementing the catchment management plan. From the safe minimum standard/minimax decision criteria, the catchment management plan is the superior strategy even in the absence of quantitative estimates for benefits of avoiding unpriced and off-site costs of dryland salinity.

Table 5.4 Minimax Decision Criterion for the Gerangamete Catchment

Land Use Strategy	States of Nature		Maximum Loss	
	Saline	Productive		
Current Land Use	B(priced) + B(unpriced)	0	B(priced) + B(unpriced)	13.46 + B(unpriced)
CMP	C - B^*(unpriced)	C - B^*(unpriced)	C - B^*(unpriced)	-13.66 - B^*(unpriced)

However, as discussed in Chapter 3, the net value of effects at the end of the project life (year 30) may not be a true measure of the insurance premium required to implement the catchment management plan, or to judge its acceptability. It was suggested that the maximum cumulative loss during the project life may be a more appropriate measure. Deterministic cashflow analysis indicated a maximum cumulative loss of \$168,845 at year seven (see Appendix G), while risk analysis provided a similar mean maximum loss of \$168,902 which also occurs at year seven (see Table 5.3). Thus, additional funding of some \$170,000 will need to be provided by farmers or the government, to establish a safe minimum standard of resource use. The \$170,000 could be regarded as the insurance premium required to provide for sustainable resource use.

5.6 Evaluation of Alternative Catchment Management Options

While the principal objective of this study was to evaluate the net social benefits of implementing the Gerangamete catchment management plan, other possible variations to the catchment management plan also need to be investigated. These are:

- to plant none of the catchment to trees (i.e. only improving all existing unimproved pasture);
- to plant 50 per cent of the catchment to trees; and
- to plant the entire catchment to trees.

The above variations were analysed stochastically, without undertaking a sensitivity analyses. The results for these variations are presented in Tables 5.5 to 5.7 While observations in many countries, including Australia have confirmed that high density tree planting can provide significant reductions in recharge than pastures under the same conditions (Peck, 1978; Oram *et al.*, 1991), the results of this study indicate that planting half or all of the Gerangamete catchment to trees will be uneconomical for the landholders in the catchment to undertake. In contrast, planting none of the catchment to trees (only improving pastures) though a highly viable investment is unlikely to have the same effect on reducing recharge as will a combination of trees and pastures as proposed by the catchment mnagement plan.

Table 5.5 Planting No Trees on the Catchment (i. e. only improving all existing unimproved pasture) ($)

		Current Landuse	CMP	Net Benefit	Peak Debt	Year of Peak Debt
Deterministic Result	NPV	13,468,904	14,906,366	1,437,463	-118,739	4
	IRR			31.52		
	BCR			1.11		
Stochastic Result	Min	11,416,980	12,796,610	1,379,637	-116,787	
	Mode	13,469,600	14,907,060	1,490,986	-118,741	4
	Max	15,722,430	17,160,170	1,437,465	-120,509	
	Std	697,321	701,092	13,561		

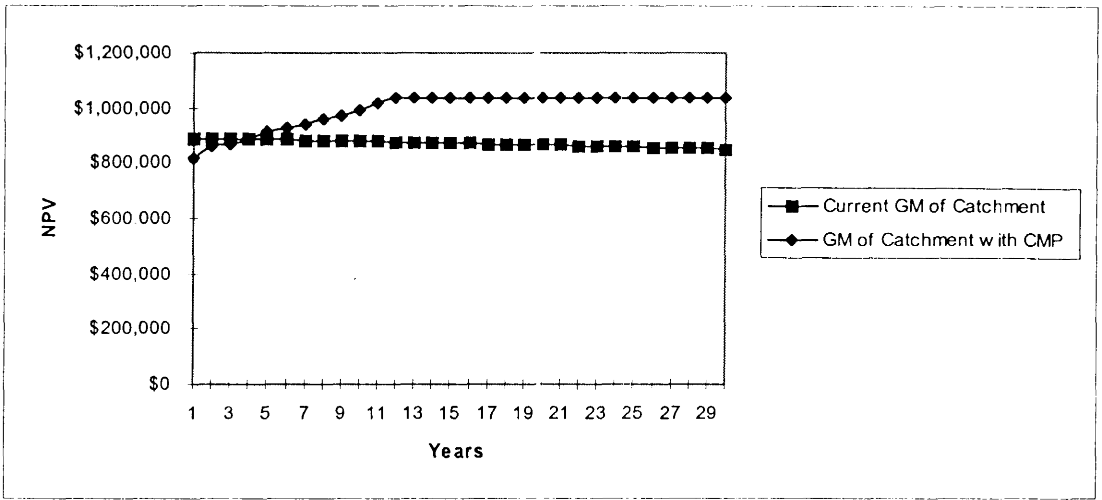


Figure 5.7 Annual Gross Margins for the Gerangamete Catchment Under Current Landuse and Planting No Trees on the Catchment (i. e. only improving all existing unimproved pasture)

Table 5.6 Planting Fifty Per Cent of the Catchment to Trees ($)

		Current Landuse	CMP	Net Benefit	Peak Debt
Deterministic Result	NPV	13,468,904	11,810,857	-1,658,047	**
	IRR			*	
	BCR			0.88	
Stochastic Result	Min	11,731,410	10,394,920	-2,236,352	**
	Mode	13,467,990	11,810,200	-1,657,791	
	Max	15,249,110	13,299,670	-1,049,117	
	Std	667,387	504,878	201,471	

* IRR unable to be calculated because of the negativity.

** Continues to be negative (i.e. current landuse gross margin is higher than the gross margin with the catchment management plan).

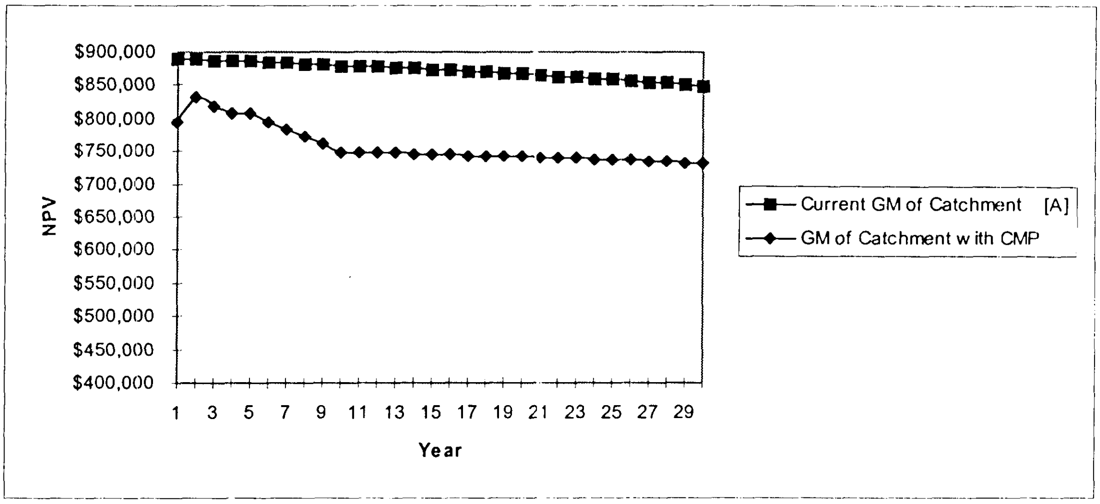


Figure 5.8 Annual Gross Margins for the Gerangamete Catchment Under Current Landuse and Planting Half of the Catchment to Trees

Table 5.7 Planting the Entire Catchment to Trees ($)

		Current Landuse	CMP	Net Benefit	Peak Debt
Deterministic Result	NPV	13,468,904	8,275,711	-5,193,193	**
	IRR			*	
	BCR			0.61	
Stochastic Result	Min	11,551,970	7,237,426	-6,678,687	**
	Mode	13,468,840	8,275,969	-5,192,870	
	Max	15,427,160	9,277,984	-3660,417	
	Std	679,042	338,679	505,408	

* IRR unable to be calculated because of the negativity.

** Continues to be negative (i.e. current landuse gross margin is higher than the gross margin with the catchment management plan).

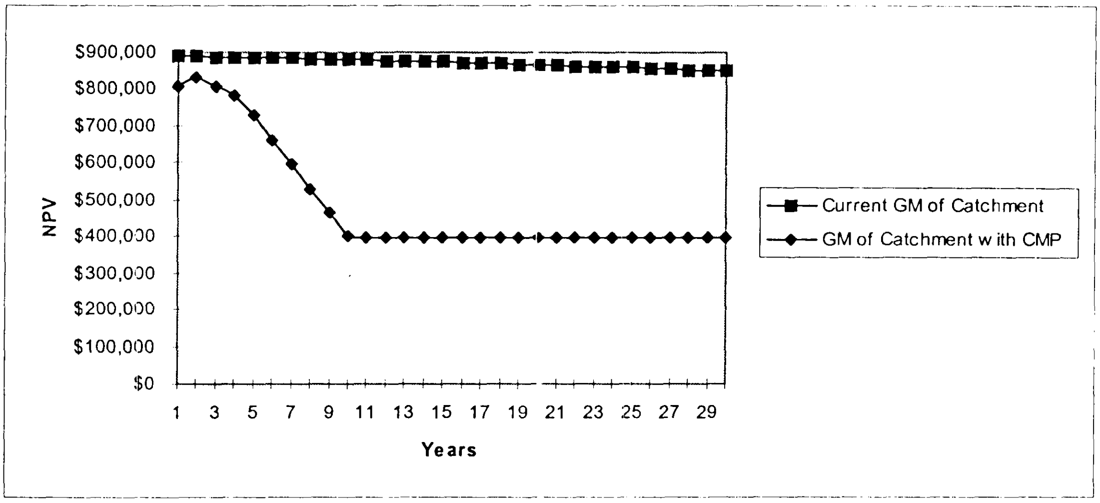


Figure 5.9 Annual Gross Margins for the Gerangamete Catchment Under Current Landuse and Planting all of the Catchment to Trees

5.7 Summary

Many of the current studies on the cost of salinity fail to include risk in the assessment. Much of the work completed on risk is the traditional sensitivity analyses. The failure to incorporate risk limits the usefulness of static models.

In this chapter the results of the study were given. A sensitivity analysis suggested that discount rate, estimates of salt affected land and the costs of tree establishment can all have an impact on the final results.

Even in the absence of quantitative estimates for unpriced and off-site effects, using net benefit results, the minimax decision criteria indicates the catchment management plan to be a marginally better strategy if society wishes to preserve the resource and is prepared to bare the loss. Implementing the catchment management plan results in a mean maximum cumulative loss of $168,902 at the end of year seven, which will need to be funded by farmers or government to ensure a safe minimum standard of resource use.

The deterministic analysis of the net social benefits (CMP-Current) indicated a net present value of $189,657, an internal rate of return of 10.27% and a cost-benefit ratio of 1.01. Although the catchment management plan is a slightly superior strategy, it is not until year 15 that total cumulative benefits outweigh the costs.

The catchment management plan was found to be first-degree stochastic dominant. Both deterministic and stochastic analysis indicate that the maximum accumulated loss will occur in year seven. There is a five per cent probability that this loss will be greater than $199,717 and a five per cent probability that it will be less than $114,729.

The break-even value, where the net present value of the current strategy equals the recommended strategy, is reached when the tree annuity benefits is decreased by 70 per cent. For the estimates of salt affected land and associated productivity loss the break-even value is reached when the rate of land loss is reduced to 70 per cent of the original estimate. The net present value for the current strategy is sensitive to changes in the rate of salinization. The ranking of strategies is not sensitive to discount rate over the one to ten per cent range accepted for social benefit analysis.

From the results of alternative variations to the proposed catchment management plan it can be concluded that while planting none of the catchment to trees would be economically viable, planting half or all of the catchment to trees would not be economic.

6. Discussion and Conclusion

6.1 Introduction

In this chapter the results are discussed in relation to the objectives, hypotheses and the safe minimum standard decision framework. The main implications that arise from the results reported in the previous chapter are also presented.

The proposed catchment management plan was found to be a superior strategy compared with present land use for reducing groundwater recharge and the spread of dryland salinity. The results are discussed in terms of the sensitivity analysis undertaken for some key decision variables and the flow of benefit and costs to landholders and government.

The safe minimum standard is also examined and evaluated for its applicability to the problem under investigation and the suitability of treating problems of economic efficiency and intergenerational equity.

6.2 Major Findings

It was found that the safe minimum standard could be used to assist decision making for problems involving uncertainty and irreversibility. The framework developed in this study was based on the minimax principle with differentiated priced and unpriced effects.

6.2.1 A Synopsis of the Study

The main objectives of this study were to identify the priced and unpriced costs to landholders and society due to dryland salinity, under current landuse and the catchment management plan. Once this information was obtained, the next objective was to calculate the net priced benefits of implementing the catchment management plan using a deterministic discounted cashfow analysis and risk analysis using Monte

Carlo type simulation. The final objective was to see if the safe minimum standard framework, developed for decisions involving uncertainty and irreversibility, could be used as an alternative decision criteria to conventional net benefit evaluation as a decision framework for the problem under investigation.

The results from undertaking both the deterministic and stochastic analysis revealed the net priced benefits of the catchment management plan to exceed the net priced benefits of current landuse practices. Thus the hypothesis that:

> Ho: That the net social benefit of implementing the prescribed catchment management plan is less than the net social benefits of current land,

can be rejected.

The minimax loss citerion and the safe minimum standard have been shown to be a useful framework for resource use issues involving uncertainty and irreversibility. The basic premise used in this framework is that the safe minimum standard should be adopted, providing the opportunity cost of doing so is not unreasonably large. The results of this study suggest the opportunity cost of the safe minimum standard is not unreasonably large from a social viewpoint.

Bishop (1978) justified the use of the safe minimum standard rule on the basis of the minimax principle. Under this principle strategies should be chosen that minimise maximum losses. Decisions, that include unfavourable long term consequences to obtain short term gains, would be unlikely to be passed by the safe minimum standard rule because of the risk of some future disasterous consequences. Bishop (1978) points out that such a decision process allows the needs of future generations to be considered, and better represented in the decision making process.

In this study the net social benefits and the maximum cumulative loss were also estimated. The maximum cumulative loss estimated under both the deterministic and stochastic analysis was found to be approximately $169,000. The net social benefit of $190,136 was positive for the time frame considered for the study. Numerous unpriced benefits from implementing the catchment management plan which would avoid irreversible resource loss were also identified, but not quantified.

In this study the minimax decision criterion was used as the basic framework for evaluating a catchment management plan, where both priced and unpriced effects are likely to result. Previous studies using such a framework have compared priced opportunity costs with uncertain benefits. To this extent, this study is different in that an attempt to identify priced and unpriced benefits, and then estimate the net benefit (priced benefits minimum priced costs) of the catchment management plan was made.

6.3 Safe Minimum Standard

The safe minimum standard originally advanced by Ciriacy-Wantrup (1952), and later by Bishop (1978, 1979, 1991) was developed as a decision rule involving environmental assets that face the risk of extinction. The general rule put forward by Bishop (1978) was that the safe minimum standard should be adopted unless the social cost of doing so are unacceptably large. The formulation of such a rule implies that society is not bound to the constraint of the safe minimum standard and that society can choose to violate the standard if the costs become unbearable.

When the safe minimum standard is formulated in game theory, it is explicitly assumed that the probabilities of alternative outcomes are unknown. In the game-theory formulation, the decision criterion is one of choosing the strategy that minimizes maximum possible losses.

Ready and Bishop (1991) showed that depending on how the problem is motivated, game theory will not always favour the selection of the safe minimum standard. At the same time they are quick to point out that this does mean the rejection of the safe minimum standard as a decision making tool, because society may choose to adopt the safe minimum standard because they feel it is "the right thing to do" (Ready and Bishop (1991, p311).

In economic terms, the cost of ensuring species survival is analogous to an insurance premium to guard against future unseen loss of assets. As such, the immediate cost must be weighed against potential future losses (Rogers and Sinden, 1993). The basic premise of the safe minimum standard is that serious or irreversible damage to the environment should be avoided, unless the cost of doing so is unacceptably high.

In this study the net priced benefits of avoiding irreversible loss were offset against net priced costs which provided the net worth of undertaking the proposed catchment management plan, which was then subjectively weighted against the future unpriced benefits.

The deterministic cashflow analysis indicates that a large proportion of the costs associated with implementing the catchment management plan will be incurred early in the project, with expected benefits resulting in later years. This is not unique to this study, but is indicative of what normally takes place in most long-term agricultural projects. Using the safe minimum standard framework developed in this, study the maximum cumulative loss should be considered as the insurance premium required to ensure the safe minimum standard. This is the true cost associated with implementing the catchment management plan, which must be subjectively weighted against uncertain future benefits. The decision criteria can now be adopted to state that the safe minimum standard should be adopted providing the maximum cumulative loss is not unreasonably large.

6.4 Policy Measures and Implications

The success of any salinity control program will ultimately depend on its ability to reduce salinity without compromising farm productivity. The adoption of salinity control measures is more easily achieved when farm enterprises are viable and profitable. In some instances farmers may have to change farm management practices in order to optimise productivity under the adopted catchment management plan.

Currently all costs are borne by specific individuals who derive a private benefit from implementing the catchment management plan. However, when farm-based control measures have demonstrated benefits beyond the individual farm, the Government may contribute to the cost of those measures. This would also mean that where the adoption of improved practices will benefit the community but penalise the individual in the short-to medium-term, the Government may provide assistance and incentives (Chisholm, 1987; Kirby and Blyth, 1987). Buttel (1993) refers to this type of action as government "policy-led sustainable agriculture". This means, '... an approach to sustainability that seeks to achieve a more environmentally sound agriculture through implementing public policies that give producers strong incentives to achieve sound environmental performance'.

In terms of the beneficiaries pay principle, the costs of implementing the catchment management plan should be borne in proportion to the benefit gained (Randall, 1972). In some cases however, strict application of this principle will slow, or even prevent, implementation of the catchment management plan. In this study, costs associated with tree growing or perennial pasture establishment, may slow the rate of adoption of these important salinity control measures. To overcome this, incentives could be offered to encourage landholders to implement these measures, even if almost all the benefit of the change in management will eventually flow to the individual landholder.

A distinction between the concept of an incentive and a grant can be identified. Incentives are intended to encourage landholders to undertake works which may otherwise not be carried out but which will have salinity control benefits. The level of assistance needs to be sufficient to act as a genuine incentive for action. A grant on the other hand, might be provided wherever works with a salinity benefit are undertaken and may be more formally integrated with the costs and benefits of the project. Assistance provided to landholders by Government should be in the form of incentives rather than grants.

Work supported by government incentives must be carried out to a high standard if government resources are to be used efficiently. Accordingly, incentives should be paid only after the works have been carried out to an adequate standard.

6.4.1 Implementation Planning

Control of salinity in the catchment relies primarily on changes in land management practices to reduce groundwater accession and to better manage the damaging impacts of salinity. Achieving this will not be simple and requires more than simply preparing a catchment management plan. Much work remains to increase the communities awareness and understanding of the threat of salinity and of the control options that are available. Other actions that may be needed include detailed farm scale planning aimed at implementing improved management and an extensive extension program to ensure the farming community is equipped with the technical knowledge and skills to tackle salinity.

The task of implementing the proposed catchment management plan is an important one. It is at this stage that local communities must take responsibility for action within their districts. It is also important that the planning for these works be undertaken at a local level, with strong community input to ensure local community ownership of the outcome (Martin and Lockie, 1993; Green, 1994). Landcare groups can play an important role as they already provide the community network upon which the implementation plans could be based.

Despite the importance of community ownership of implementation planning, the process cannot be allowed to develop in an *ad hoc* fashion. Planning needs to be coordinated and resources allocated according to priority areas. It will therefore be necessary for government extension and community education officers to actively encourage landholder groups to take an interest in the catchment management plan, to identify opportunities for implementation at a local level and to establish the necessary arrangements for community involvement in local implementation planning.

Control of salinity requires that all land managers develop a good technical understanding of the land and water processes involved in salinity, and of the salinity management options available to them. An additional challenge for the pastures program is the need to consolidate any gains made by ensuring farmers have the skills and knowledge to manage pastures so that they will persist.

6.5 Implications of the Results

The hydrological model developed for this study is designed to find the long-term optimal land use patterns for the Gerangamete catchment. Combined with the economic methodology adopted in this study it enables one to estimate the cost of dryland salinity and the costs and benefits of implementing the catchment management plan. In other words, the financial implication of a safe minimum standard can be calculated. This will provide a basis for designing policy measures that establish a salinity abatement strategy equitably borne by the local landholders.

Another application of the model is in policy analysis. The results could also assist (both local and State) governments with setting future land and water policy for the region. For example, taxes or subsidies may be necessary to ensure that salinity control becomes financially viable for those landholders required to accept preferred chanes in land use.

Due to its flexibility, the hydrology model could also be adapted to other studies of this nature to find the best strategies for dryland salinity management. If the resolution of the data deficiencies identified in this study are made, the model could also assist in setting future research and investigation programs in the south west region.

6.6 Limitations and Proposals for Future Research

This analysis is based on an interpretation of technical, economic and social information available in 1997. Advantage has been taken of recent research and review of projects, but some aspects of this study have been developed on assumptions that have yet to be tested. Others are based on an incomplete understanding of the physical and biological environment of the catchment.

Part of the implementation of the catchment management plan therefore requires further research and investigation aimed at overcoming the gaps in knowledge, and to confirm (or disprove) some of the assumptions used. These tasks may require further modelling. To this end, appropriately planned and managed monitoring will be vital.

Monitoring of a series of key indicators will also be necessary to evaluate the effort being put into any proposed implementation program and the benefits gained. It is also vital to raise community awareness and stimulate action at a local scale.

While the use of the safe minimum standard has been shown to be a valuable decision framework for decision making under pure uncertainty and irreversibility it does have some limitations. Tisdell (1990) argues, that while preservation of species may be favoured under the safe minimum standard rule, it does not provide a guide for determining which species should be conserved. The safe minimum standard rule also suggests that the safe minimum standard should be adopted unless the social costs of doing so are unacceptably large (Bishop 1978, p10). This begs the question as to how high the opportunity costs would have to be before it is considered to be excessive by society (Rogers and Sinden, 1993). This is a decision that only the present generation can make to reduce uncertainty and irreversibility for future generations.

Ready and Bishop (1991) showed that depending on how the problem of species preservation is motivated, the conclusions reached using the minimax loss decision rule could be completely reversed. They showed that the safe minimum standard cannot be motivated as the minimax-loss solution to a two person game against nature. Rolfe (1995) suggests that the safe minimum standard can be used as a flagging mechanism for issues of particular interest. They suggest that the safe minimum standard approach cannot be used on its own, for precision and ranking of priorities but should be tied to the traditional cost-benefit analysis. Its use, they suggest, is as a signal to switch to a more intensive examination of costs and benefits, and is justified in this format because the benefits of more accurate decisions outweigh the costs of operating the safe minimum standard rule (Rolfe, 1995).

Modelling salinity and its spread requires obtaining detailed data. This study was fortunate that 10 years of data was available for many of the key parameters. This enabled more accurate modelling of the hydrology of the catchment. Unfortunately, not all catchments will have such detailed information, which may compromise the ability and accuracy of any long term projections.

From the framework developed in this study it has been demonstrated that there is unlimited potential to use a determin stic (static) system in conjunction with a simulation based evaluation system for analysing projects involving uncertainty and resource loss. In this way it is hoped to provide a more useful information base for developing land use policies and guidelines.

Future research can focus on refining and developing this framework for application to a range of similar resource use problems involving uncertainty and irreversibility. Comparisons however can only be made between similar projects exhibiting similar characteristics in terms of unpriced and priced benefits. For this reason, Rolfe (1995) suggests that the Safe minimum standard rule should have a CBA rationale, as this would allow the comparison of costs aga nst different standards of preservations.

6.7 A Final Word

In this study the decision criterion developed by Ready and Bishop, is used to evaluate a proposed plan to reduce the spread of salinity and groundwater recharge. To do this requires a more sophisticated approach than the static method of most spreadsheets. Although it is easy to change and recompute evaluations, a practical limit exists to the number of 'what if' scenarios that can be readily obtained. Risk analysis using @Risk provides a powerful solution to this problem. In Australia, where production risk plays a major role in land use, there is a strong case for it to be included in land evaluation.

It was found using these techniques that the Gerangamete catchment management plan would be beneficial. Local government has already responded to the increasing concerns about dryland salinity by establishing Landcare and catchment management schemes, placing bans on tree clearing in some areas, funding research and investigation programs on specifically affected sites and providing information thorugh government funded extension programs. Co-operation between community groups and local government must continue if effective long-term salinity control in dryland areas is to be achieved.