The Economic Value of Irrigation In New Zealand

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Foreword

This paper was developed by MAF Policy Information and Regions Group staff to provide information on the socio-economic contribution irrigation currently makes to the New Zealand economy, and an estimate of the potential to add to economic growth.

The purpose of the analysis, which was initiated before the Programme of Action (PoA) on water was started, is to examine the economic contribution of current and potential water use through irrigation in the knowledge that the benefits of water for other uses are being addressed separately.

The report therefore makes no judgement on the relative merits to other complimentary or competing water uses.

The report has been released in MAF's Technical Paper series to make the information more widely available to the range of stakeholders who have an interest in the impacts, management and allocation of water.

The calculations have been done on data from the 2002/03 production season, as this is the year for which information was most readily available. Farm product prices for most products were down from the peaks experienced in the preceding two seasons, and more in line with medium term average prices. The results therefore reflect the order of magnitude of the average contribution irrigation makes to the New Zealand economy at farm gate in recent years. The section on social values brings together the key findings of several research projects conducted in recent years.

The contribution of water to the national interest has many forms. The socio-economic value of irrigation is only one of them. There are also very important conservation, environmental, recreational and cultural values of water. The use of water for irrigation can impact on all these values in various ways, some positive and some negative. Development and management of the irrigation farming system can have a significant bearing on the impacts of irrigation on these other values. These aspects are not addressed in this paper, but the intention is that the information contained in this paper be considered alongside information on these other interests.

I would like to acknowledge the efforts of MAF Policy staff and external contributors to the assumptions and data used in this analysis. It is our expectation that the release of the report will stimulate discussion around some of the assumptions and data. It is our intention to test the significance of these in further analyses.

I commend this report to all that have an interest in water allocation and use.

Alan Walker
Director
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Executive Summary

This paper calculates the contribution of existing irrigation to the national economy in 2002/03 and uses the same methodology to estimate the potential contribution of further irrigation development.

The method adopted follows a "with minus without" irrigation approach, adjusted for changes in farm type and scale. The result is an indication of the contribution irrigation makes to farm-gate GDP in the 2002/03 season.

The net contribution of irrigation to GDP at the farmgate is estimated to be in the order of $920 million in 2002/03. This is over and above GDP that would have been produced at the farmgate without irrigation. Total farmgate contribution of all primary production excluding forestry is estimated to be $8.1 billion in 2002/03 (SONZAF 2003[1]), so irrigation contributed in the order of 11% of farmgate GDP in that year. This is produced from 475,700 ha of land, which is 3.9% of the12.1 million ha farmed (excluding forestry). Assuming all the extra production is exported, the value of these exports is in the order of $1.7 billion (12% of total agriculture and horticulture exports).

Variations between land uses and regions are interesting. Horticulture land uses, including viticulture and vegetables, contribute $550 million (60%) of the total, and dairy farming $270 million (29%). Canterbury has 287,000 ha (60%) of irrigated land, which contributes $330 million (36%) of the total, or $1160/ha irrigated reflecting the generally lower value of land uses in that region. Hawke's Bay has 18,100 ha of irrigated land, with each hectare contributing on average $5,500 of farmgate GDP.

Irrigated land uses employ in the order of 5,000 full time equivalents on farms and horticulture units. Flow-on impacts through the rest of the economy are not included in these calculations.

The same methodology was applied to different irrigation development scenarios to derive an estimate of the contribution to farmgate GDP from future irrigation development in 10 years.

Two scenarios were investigated. Scenario 1 assumes the irrigated area increases by 201,000 ha by 2013 (the "likely" scenario). This consists of about 84,000 ha of private development and 117,000 ha of community scheme development, based on a report for the Ministry for the Environment in 2000.

Scenario 2 assumes the irrigated area increases by 470,000 ha by 2013 (the "possible" scenario). This is based on the same rate of private development as in Scenario 1 and a greater number of community schemes being operational in 10 years. The community scheme area was from a survey of the 21 community irrigation proposals currently at various stages of investigation.

Future land use was estimated by MAF Policy regional staff for private developments and by the promoters of each community scheme. At 2002/03 prices and production levels, the calculation showed that by 2013 annual farmgate GDP could be increased in the order of an additional $330 million ($1,640/ha) under Scenario 1 and $660 million ($1,400/ha) in Scenario 2.

[1] Situation and Outlook for New Zealand Agriculture and Forestry, MAF Policy Dec 2003. Source: http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/sonzaf

Gross margin calculations generally assume that a change in output has no effect on prices. However, large-scale land use changes generated by irrigation on the national scale to date are likely to have had some measurable effect on output prices.

These impacts were modelled using the Lincoln Trade and Environment Model (LTEM). The model only covers dairy, lamb, wool, beef, kiwifruit and apples, which together make up about 45% of the output from irrigated land uses. The modelling indicates that current prices for these products would be slightly different if the 475,700 ha of current irrigation was in dryland farming systems. When applied across all New Zealand's output of those products, this has the effect of reducing the calculated contribution of irrigation to GDP by the order of $100 million (from $920 million down to $820 million).

The change in output from future irrigation is likely to also have very little impact on price even at the most optimistic estimates of output change. The exception to this is kiwifruit. These price changes applied across all New Zealand's forecast output of LTEM products in 2013 result in a fall in the contribution of irrigation to GDP in the order of $80 million. However, influences such as marketing programmes are not taken into account in the modelling, and there is no ability to model the products not covered by the LTEM, so this result is indicative only. The price results are reasonably insensitive across the range of output scenarios considered.

There are several other measures of national interest that could be used. All economic ones could be based on the information in this study with appropriate adjustments. Measures of social, environmental, cultural, and recreational values could be examined alongside these economic measures in seeking to optimise the combination in New Zealand's national interest.

1 Introduction

The brief for this paper was to determine the national economic contribution of irrigation in New Zealand, and the potential net contribution of further irrigation development to future economic growth. The information is primarily intended for MAF Policy to use in providing advice and information to government, and to provide context for the Sustainable Development Programme of Action (SDPoA).

2 Background

From the time of the earliest schemes up until the1980s, government policy considered irrigation to be in the national interest for the production of increasing amounts of primary products. Social and environmental outcomes via soil conservation and drought proofing of farms were also considered important and complementary to irrigation. Under various pieces of legislation[2] a number of rivers were modified to provide both electricity and irrigation, with primacy for these values over the natural and conservation values of the rivers.

In many cases, these modifications are now seen as part of the current production and amenity environment, and provide many positive values to many people, albeit a different set to those that would have been there had the rivers not been modified.

In the decade leading up to the Resource Management Act (RMA) in 1991, there was increasing community pressure to provide a better balance between economic development and conservation, environmental and social values. Even so, irrigation development since 1991 has continued at a similar rate to the pre-RMA period. Although precise comparative figures do not exist, the irrigated area in New Zealand is believed to have doubled in the period from 1985 to 1995 (Robb, 2000[3]). Significantly though, only two community schemes (Waimakariri and Opuha) have been developed through this period. Other development has been by individual irrigators.

Over the period from the 1930s up to 1984 there was considerable direct public investment in community irrigation schemes. In the 1930s, the provision of irrigation was secondary to the provision of work in building the schemes. Since a change in policy in 1985 there has been no direct central government investment in building irrigation schemes. Many New Zealanders know little about the role of irrigation in maintaining and enhancing our economic base. Through the 1990s, agriculture was viewed by some as a “sunset” industry. In recent years, agriculture has been increasingly recognised for its role as the underpinning economic engine of the New Zealand economy[4]. The role of irrigation has also changed from drought proofing or insurance to being the means by which farmers and therefore the economy can diversify, and meet market expectations for quality and quantity of produce because of the increased control irrigation provides over a major production variable. In the future, as New Zealand is exposed increasingly to competition in world markets from lower cost economies, irrigation will be important to enable the agricultural sector to quickly respond to market signals on product quality, quantity and composition in niche markets. The application of biotechnology to our current and emerging land uses brings with it an even greater requirement for certainty of achieving produce of a specified quality and quantity, as a considerable investment has often been made in developing the technology to the point of production.

[2] National Water and Soil Conservation Act 1967 being the main one
[3] Information on Water Allocation in New Zealand – April 2000, Ministry for the Environment www.mfe.govt.nz/publications/water
[4] The Contribution of the Land-based Primary Industries to NZ’s Economic Growth – 2003, for the Growth and Innovation Advisory Board. www.maf.govt.nz/mafnet/publications

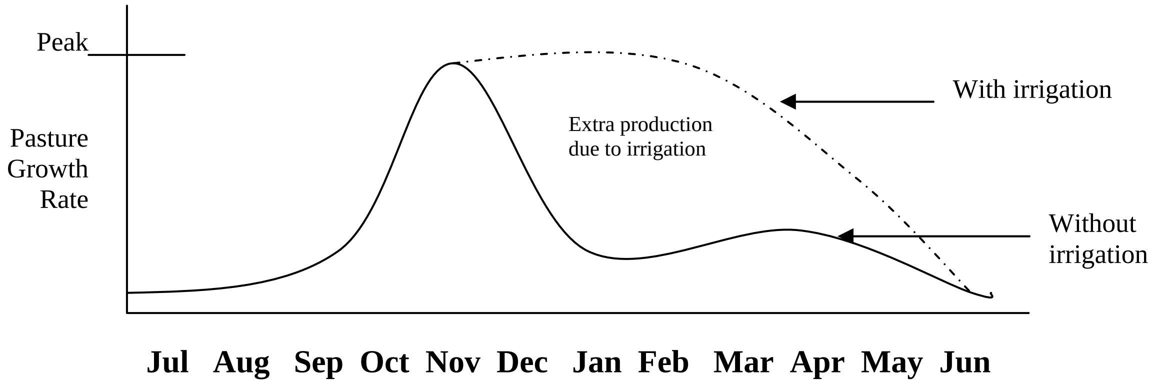
At the same time as wanting to maintain socio-economic growth, New Zealanders have higher expectations about the maintenance and enhancement of environmental and conservation outcomes from water use than was the case 20 years ago. Generally, an optimisation[5] approach to these values is likely to be the way of the future. This will involve all New Zealanders understanding the role of water in the economy, the ways that combinations of desired outcomes can be achieved without necessarily excluding one or other use, and the trade-offs that are sometimes necessary to achieve this in the national interest. Therefore the place of irrigation in future will likely be very different from the past.

[5] Note that "optimisation" is not the same as "multiple use" in the way the 1967 National Water and Soil Conservation Act operated.

3 What is irrigation?

Irrigation[6] replaces water, the essential ingredient of life, lost by the biophysical processes of plant growth and evaporation. It therefore supplements and augments rainfall to remove or reduce the influence of climatic variability on the lands' productive capacity. Figure 1 illustrates the concept of extra pasture production from irrigation.

Fig. 1 Stylised pasture production profile



Note that rain is natural irrigation and can have similar effects but in a less controlled and predictable way. The more variable or low the rainfall in a particular region, the more valuable irrigation is likely to be, on suitably contoured land, in supporting a particular land use or combination of land uses in that location. The relative value can change over time with climate, market requirements, costs and technology.

The management of the water and the use to which it is put will determine its value (or otherwise). This implies that anywhere can benefit from irrigation to provide certainty about water. The question of whether it has a positive or negative net value is an economic one and a function of investment, time, consistency, risk, value of the product and natural rainfall quantity and patterns e.g., Waikato vs Canterbury. Most production systems can be undertaken without irrigation, but such is the variation and risk in the system that some particular land uses in some particular locations would be financially non-viable without it. By guaranteeing the availability of one of the variable productive resources the irrigator is able to optimise the utilisation of other fixed and variable factors of production (land, labour and capital).

There are also intangible or indirect impacts, such as peace of mind, increased land values, increased owner labour, increased scale of the production unit, and off-farm impacts such as population redistribution, employment creation, environmental impacts, demand for services and investment in processing plants.

[6] Irrigation is "the artificial augmentation of the amount of water available to crops [or pasture], either by spraying water directly on to the plants or making it available to their root systems through a series of surface channels or ditches". Source - A Dictionary of Ecology. Ed. Michael Allaby. Oxford University Press, 1998. Oxford Reference Online. Oxford University Press. <http://www.oxfordreference.com/views/>

4 The value of current irrigation to the New Zealand economy

Irrigation alone does not provide an economic return, but can allow production and/or product quality levels to be lifted on any given piece of land, or the land use to be determined from a wider range of options. However, gaining an economic return on the irrigation investment usually requires increases in the use of other inputs. This leads to considerable increases in economic activity and usually, but not always, in profit per unit of employed capital or the margins of the agricultural enterprise.

Therefore it is important to be aware of the reference point in describing the value of irrigation. To an individual irrigator, irrigation may be the difference between being a viable business or leaving the industry. From a national point of view, the products that particular farmer produces may be produced by someone else in a different part of the country or under a different production system. Furthermore, there are costs associated with this increased activity. However, although there may be substitution of some production, the total output (volume and value) of production for the country will rise with irrigation.

This report builds on an earlier report (Robb, 2000) which made a preliminary estimate of the farm-gate value of irrigation. The current report improves on the 2000 estimate in a number of ways (described in section 4.6). The following calculation calculates the net value of irrigation to the New Zealand economy.

4.1 METHOD

Appendix 1 contains a full description of the methods considered and the reasons why the approach taken was adopted. Key assumptions by land use and region are described in Appendix 2.

The method adopted follows a "with minus without" irrigation approach, adjusted for changes in farm type and scale. The result is an indication of the contribution irrigation makes to farm-gate GDP.

The formula is:

Farmgate GDP due to irrigation = GDP with irrigation – GDP without irrigation.

= (irrigated land use mix x (irrigated GM – fixed costs)) – (dryland land use mix x (dryland GM – fixed costs)).

The gross margins were determined for farm types and regions throughout New Zealand by regional MAF Policy staff and their contacts. The gross margins are those for the 2002/03 season. A single season was used because the irrigated land use data available related only to that year. Prices in this year were at neither particularly high nor low levels compared to preceding years and the forecasts for future prices[7]. The result is therefore for a single year, but can be considered indicative of the order of magnitude of farmgate GDP attributable to irrigation.

The "without irrigation" land use is that which would now exist if irrigation had not been developed, rather than if irrigation was no longer available for that particular land.

[7] Situation and Outlook for New Zealand Agriculture and Forestry 2003, MAF Policy

The revenue and cost information was derived from gross margins representing average current productivity levels by land use and region. These were adjusted to account for the different fixed costs associated with different farm types or scales, using primarily data from MAF's Farm Monitoring models. To improve these estimates, for example to use at a sub-regional level, full budgets for irrigated and non-irrigated systems under each land use should be created, but this was beyond the scope of this study. The 2000 study (Robb, 2000) did not account for the likely increase in fixed costs associated with the change from dryland to irrigated production.

The differences in the adjusted net farmgate value were added within regions and aggregated up to the national level to give an estimate of the value added by irrigation at the farmgate. This approximates the contribution of irrigation to GDP at the farmgate in 2002/03.

Note there will be some additional flow-on positive impacts on GDP in other sectors of the economy (e.g., processing and servicing industries) due to irrigation. However, this flow-on impact is not included in this calculation. To do so properly would require the development of a model of the economy without irrigation. While approximations could be made from standard Input/Output tables, the results would be based on some very broad assumptions. Given the magnitude of possible errors associated with assumptions about land use, productivity, costs and returns inherent in this study, estimating the flow-on impacts through the economy, real as they are, would not provide useful information without more detailed modelling than has been undertaken in this study.

4.2 IRRIGATED AREA

Identifying the area irrigated has proved more difficult than anticipated, as data is scarce and what is available is incomplete and in some cases contradictory. The Statistics NZ/ MAF Agricultural Production Census (APC[8]) of 2002 asked a question about the area farmed during the year ended 30 June 2002 that were 'under an irrigation system'? That is, how much of the farm was it possible to irrigate? The results from this census became available in June 2003 at a regional level, but are not yet available at the regional level by farm type. Therefore the project team sought the assistance of MAF regional staff and their contacts to identify irrigated land use for each region for this project.

Table 1: Irrigated area by region

	Area Under an Irrigation System (ha)	
Region	MAF Estimate 2002/03 season	APC 2002
Northland	7,000	7,000
Auckland	7,900	6,300
Waikato	14,500	12,700
Bay of Plenty	11,400	8,800
Gisborne	5,600	1,300
Hawke's Bay	18,100	18,100
Taranaki	2,900	2,900
Manawatu-Wanganui	8,000	8,000
Wellington	9,600	9,600
Tasman	10,000	10,000
Marlborough	20,200	20,200
West Coast	-	2,500
Canterbury	287,200	287,200
Otago	68,900	68,900
Southland	4,100	4,100
Totals:	475,700	467,500

[8] "Agriculture Production Census 2002 – Source: http://www.stats.govt.nz/demmo/external/web/prod_serv.nsf/response/irrigation+tables

The middle column of Table 1 shows the area under irrigation used in the calculation of the national interest, while the third column shows the regional total areas under irrigation systems from the APC 2002. The relatively small differences arise where regional MAF staff, through their contacts and local knowledge, believes that the APC estimates are lower boundary estimates of the area of land which was able to be irrigated during the year ended 30 June 2002, and therefore increased the area in those regions. For some regions, notably Canterbury, the APC area was used because there is no other basis on which to estimate the area under irrigation.

The exercise of obtaining an estimate of the current area able to be irrigated has raised questions about the accuracy of the APC figures. The estimates provided by MAF regional staff, confirmed with contact with industry and Regional Councils, indicate that the APC results for the area currently able to be irrigated appears to be understated. As an example of MAF concerns, Environment Canterbury has issued consents for water applied to 440,000 ha of land. The area able to be irrigated is likely to be somewhat less[9], but is likely to be greater than the 287,000 ha from the APC. A simple comparison of number of farms with land able to be irrigated (from APC confidential information) compared to the number of consents issued is further evidence of the APC 2002 area being understated. The area able to be irrigated nationally used in the 2000 estimate was 510,000 ha and was based on consents information and previous surveys.

The 2002 APC was the first Statistics New Zealand agricultural production survey to include a question concerning irrigation since the mid 1980s. Wording presented difficulties to some respondents, particularly ‘under an irrigation system’, and data may have been omitted where it could have been expected. Wording was tightened for the 2003 survey to read “How much of the land you farm was able to be irrigated with an existing system?” A preliminary assessment of 2003 data indicates improved response (Guy Sanders, Statistics NZ pers com). This information will be available in the next few months.

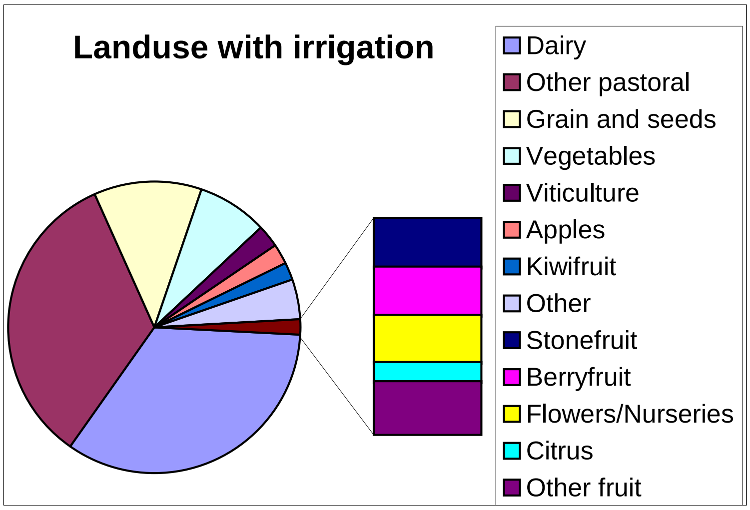
4.3 LAND USE

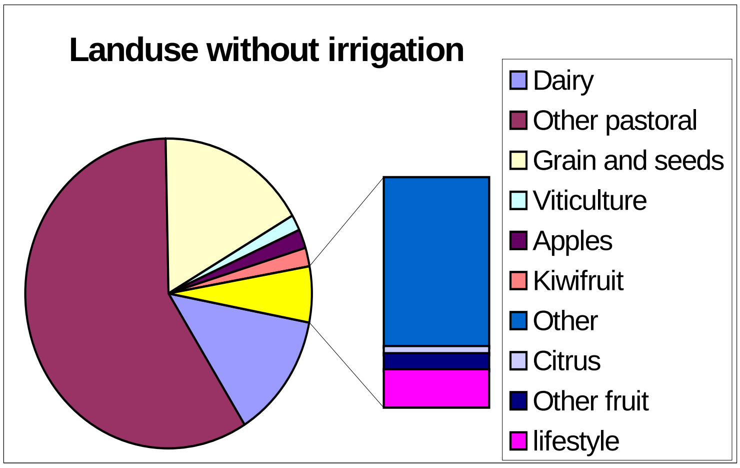
Regional MAF staff and their contacts estimated the land use of currently irrigated land and its use if those areas were in dryland farming systems from a combination of Statistics NZ information and local knowledge. Table 2 shows the totals for New Zealand, aggregated up from the regional assessments. The assumptions applied are described by region in Appendix 2. In each case, the determination of land use without irrigation was a judgement based on physical factors such as soils and climate, but also on the commercial realities of current primary production in New Zealand. For example, while vegetable crops can be grown successfully on dryland, in most cases the market demands for consistency of yield and quality mean that without irrigation, that particular land use would not be commercially viable.

[9] Due to some farms having more than one consent, and/or irrigation of a smaller area than described in consent database

Table 2: Land use assumptions for current irrigated areas

Land use	Area with irrigation (ha)	Area without irrigation (ha)
Dairy	161,500	62,000
Other pastoral	159,100	279,500
Grain and seeds	57,300	80,400
Vegetables	37,200	-
Viticulture	11,200	7,400
Apples	10,800	9,600
Kiwifruit	9,400	8,900
Other	20,700	20,700
Stonefruit	2,000	-
Berryfruit	1,900	-
Flowers/Nurseries	1,800	-
Citrus	800	800
Other fruit	2,000	2,000
Lifestyle	-	4,400
Total	475,700	475,700





As a result, some land uses are likely to have occurred with or without irrigation in parts of some regions, although with lower Gross Margins e.g., dairy farming is assumed to have occurred on heavy soils in Canterbury where it currently exists. Likewise, grapes are assumed to be grown in some parts of Hawke's Bay and Marlborough even under dryland as the profitability is considerably higher than the next most valuable land use.

4.4 PRICES AND COSTS

The value of irrigated production and the value of production from the dryland use that would be most likely if there was no irrigation were derived from MAF regional staff and their contacts in agribusiness and industry. Details of gross margins are in some cases subject to commercial sensitivity constraints and have been given to MAF staff on that basis. A summary of gross margins and fixed costs appears in Table A2.3 in Appendix 2. The price assumptions are summarised in Table 3.

Table 3: Price assumptions used

Price assumptions used	
Milk	$3.70/kgMS
Meat[10]	$3/kg average all grades
Venison	$5/kg average all grades
Apples	$17/TCE
Kiwifruit	$5.25/tray
Grapes	$1,500-$2,000/tonne depending on variety
Other crops (Hort & Arable)	Average grower returns last 3 years Average quality of produce

4.5 RESULTS

The net contribution of irrigation to GDP at the farmgate is estimated to be in the order of $920 million in 2002/03. This is over and above GDP that would have been produced at the farmgate without irrigation. Total farmgate contribution of all primary production excluding forestry is estimated to be $8.1 billion in 2002/03 (SONZAF 2003[11]), so irrigation contributed in the order of 11% of farmgate GDP in that year. This is produced from 475,700 ha of land, which is 3.9% of the12.1 million ha farmed (excluding forestry).

The calculation is a function of irrigated area, land use, productivity and value of production.

Table 4 summarises the results of the calculation. Appendix 3 contains these results by sector and region.

[10] In this calculation, sheepmeat and beef are combined together in a weighted price based on assumed stocking ratios and age classes. Base prices used are $3.50/kg for prime lamb, $1.70 for mutton and $3/kg for prime beef.

[11] Situation and Outlook for New Zealand Agriculture and Forestry, MAF Policy Dec 2003. Source: http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/sonzaf

Table 4: Net contribution of irrigation to farmgate GDP

Region	Irrigated Area hectares	Net Value of irrigation $million per annum	Value per hectare irrigated $/ha per annum
Northland	7,000	29	$4,110
Auckland	7,900	54	$6,880
Waikato	14,500	56	$3,840
Bay of Plenty	11,400	39	$3,440
Gisborne	5,600	25	$4,530
Hawke's Bay	18,100	99	$5,480
Taranaki	2,900	6	$2,070
Manawatu-Wanganui	8,000	21	$2,620
Wellington	9,600	21	$2,270
Tasman	10,000	47	$4,660
Marlborough	20,200	86	$4,250
Canterbury	287,200	335	$1,170
Otago	68,900	87	$1,270
Southland	4,100	13	$3,170
Totals:	475,700ha	$920M	$1,930

Note numbers may not add due to rounding

4.6 DISCUSSION

This result is conservative for the following reasons:

1. Areas irrigated are likely to be larger than available data sources suggest by an unknown amount.
2. Gross margin analysis does not account for fluctuations in output over time. Downside fluctuations are likely to be greater under a dryland scenario than under irrigation.
3. The benefits of irrigated farms that flow to dryland farms are not accounted for (e.g., growing feed crops for dairy herds). If they were it would have the effect of further increasing the value of irrigation.

Of these qualifiers, the first is being addressed but may not be able to be resolved completely. The second has been taken into account to a degree in assuming that some land uses would not occur without irrigation. Even so, the fluctuations in dryland pastoral incomes are demonstrably larger than for irrigated areas (Butcher 2000[12]). The third is difficult to demonstrate, although evidence of the value of having irrigated properties in reasonable proximity to dryland ones is contained in other studies.

As noted in section 4.0, this project updates the 2000 figures used in the study of Water Allocation in New Zealand (Robb, 2000). At that time, the value using similar methodology was estimated to be $1 billion. The main differences between that result and this one are:

- The dairy payout used in 2000 was $5/kgMS compared with $3.70/kgMS in 2002[13].
- The area irrigated was estimated without APC data in 2000 at 510,000 ha. As noted, for this project the irrigated area is estimated at 475,700 ha but is likely to be higher.
- The horticulture value was very crudely estimated in 2000. In this study, the area and value from irrigated horticulture has been considerably refined.
- An adjustment for fixed costs was made in this study to reflect different farm types and scales with and without irrigation.

[12] Regional Economic Impacts of the 1997-1999 Canterbury Drought, Butcher Partners Ltd and Agriculture NZ, Feb 2000, MAF Technical Paper 00/18.
[13] Inserting $5/kg into the gross margins increases the net value by $150m. However, it must be remembered that spending tends to increase as well so not all of this increase would contribute to farmgate GDP.

4.7 OTHER NATIONAL ECONOMIC IMPACTS

There are a number of parameters that could be chosen to report the national interest and no one parameter is able to reflect a complete picture. A study for MAF[14] developed parameter values that recognised the need to assess both direct and indirect impacts and came up with the following assessment parameter values.

- Profitability (measured by ROC)
- Output
- Employment
- Value Added
- Location of impacts

This project focuses on calculating the economic value added by irrigation at the farmgate. Other measures are described below.

The calculation of current contribution of irrigation to economic output has no assessment of the flow-on effects to the rest of the economy via increased inputs or products. These are not zero. But to calculate them accurately would require the development of a model of the economy without irrigation. While approximations could be made from standard Input/ Output tables, the results would be based on some very broad assumptions. Given the magnitude of possible errors associated with assumptions about land use, productivity, costs and returns inherent in this study, estimating the flow-on impacts through the economy, real as they are, would require more detailed modelling than the scope of this project allowed.

Irrigation increases economic activity and farm capital values. The latter allows more borrowing, which again increases economic activity. However, more economic activity per se does not necessarily benefit the country – although the perception of many irrigators is that it does. To illustrate by analogy, large construction projects undoubtedly raise economic activity during the construction phase, but some prove to be unprofitable, and some of the money invested would arguably have generated higher returns if it had been invested elsewhere in the economy. In the same way, if the money invested in irrigation results in lower net profit per hectare (despite higher gross revenues), or could be more profitably invested elsewhere, then New Zealand is not better off. However, for irrigation schemes currently proposed or which were developed in the last 20 years this is an unlikely scenario[15]. This is because those investing in irrigation since the mid 1980s have been doing so in a relatively undistorted investment market, with good information on the costs and benefits of the investment. Further work on return on investment could be undertaken as another measure of national interest.

Irrigation also increases foreign exchange earnings. Of the increased output resulting from irrigation, most, if not all, of the dairy, sheep, beef, deer, horticultural and seed products would be exported. Using 2002/03 FOB prices, these net increases in exports are worth $1.7 billion FOB, or 12% of total horticultural and agricultural export earnings in 2002/03.

Increased land use intensity results in more employment opportunities on farms. As discussed in Appendix 1, wages and salaries paid to employees remain within the calculation of GDP in section 4.5. Using the same land use assumptions with and without irrigation, and taking the salaries and wages paid to employees from Farm Monitoring models for each of these land uses can give an approximation of the employment created by irrigation. For the current irrigated area, $158 million of wages and salaries are generated from irrigated land uses net of

[14] Economic and Social Assessment of Community Irrigation Schemes, Ford S., MAF Technical Paper 2002/13
[15] MAF Technical Paper 2002/13 reports the Lower Waitaki Irrigation Scheme returns 14% per annum on capital at the farmgate.

that generated from the alternative dryland land use. At $30,000 per employee, this is the equivalent of 5,300 FTE's. This estimate is corroborated by the study of irrigation impacts in the Lower Waitaki (Ford 2002[16]) which calculated 10.4 extra FTE's employed on farms per 1,000 ha irrigated. Extrapolating nationally over 475,000 ha also suggests around 5,000 FTE's are employed on farms due to the presence of irrigation.

The key question is whether New Zealand as a whole is better off from an investment in irrigation or whether those funds are better invested in other ways. This study provides some information on the contribution of irrigation, but there needs to be a framework developed to compare this investment with alternative uses for the investment capital. Therefore, further analysis of alternative investments that can be compared in cost benefit terms with irrigation development is required to determine if indeed New Zealand is better off from developing more irrigation or from investing in other development opportunities. This is discussed further in Appendix 1.

[16] Economic and Social Assessment of Community Irrigation Projects, S Ford, Dec 2002, MAF Policy Technical Paper 2002/13.

5 Value of potential new irrigation to add to economic growth

The irrigated area continues to grow from private individual development. In addition, there are currently approximately 30 community scheme proposals at various stages of investigation and several more being considered by community groups. This section examines the potential of both the private and community proposals to add to economic growth, the production and price implications of these, and discusses the ways in which this economic growth may be achieved.

5.1 METHOD

The same methodology used in section 4 was applied to different irrigation development scenarios to derive an estimate of the contribution to farmgate GDP from future irrigation development in 10 years.

The scenarios investigated are:

Scenario 1 Private development continues at the present rate and some community schemes are developed (the "likely" scenario).

Scenario 2 Private development continues at the present rate and community schemes that were assessed by their promoters as being possible to have operating by 2013 are developed (the "possible" scenario).

Scenario 1 was based on a recent report for the Ministry for the Environment. Scenario 2 was partially based on the same report in that it used the increases assumed in private irrigation development of 84,000 ha. Added to this was information obtained directly from community scheme promoters by MAF Policy regional staff during July/August 2003. The information includes estimates of area to be irrigated in 10 years, the land uses of the scheme area now and an estimate by the scheme promoters of what that land will most likely be used for under irrigation.

5.2 AREA, LAND USE AND PRICE ASSUMPTIONS

The areas estimated and assumptions are included in Appendix 3. Scenario 1 suggests irrigated area will increase by 201,000 ha by 2013, made up of 84,000 ha from private development and 117,000 ha from community scheme development in the South Island[17]. Scenario 2 uses the same rate of private development as Scenario 1 (84,000 ha) and adds 386,000 ha of community scheme development to give a total possible increased irrigation area of 470,000 ha by year 2013. The 386,000 ha of possible community irrigation development was obtained from a survey of the 21 community schemes currently in various stages of investigations by community based groups.

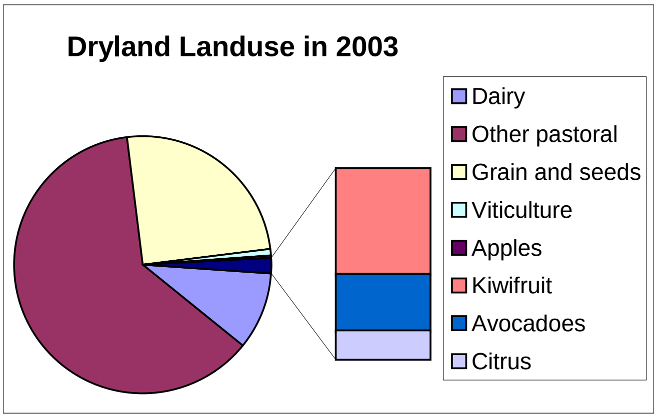
Tables 5 and 6 shows the current dryland land uses for Scenario 1 and 2, and the land uses assumed for the same land with irrigation in 10 years time for the whole of New Zealand. In the case of the community schemes, the land use with irrigation was estimated by the scheme promoters.

[17] A Review of Land use Projections for 2010 and Implications for Water – S Ford, The Agribusiness Group, August 2003 for the Ministry for the Environment.

Table 5: Land use assumptions for likely future irrigation (Scenario 1)

Land use	Current Area without irrigation (hectares)	Area in 2013 with irrigation (hectares)
Dairy	19,300	67,900
Other pastoral	125,500	55,200
Grain and seeds	50,000	40,100
Vegetables		22,300
Viticulture	2,000	6,100
Apples	300	1,500
Kiwifruit	2,200	4,200
Berryfruit		500
Avocados	1,200	2,200
Citrus	600	1,000
Other fruit		100
Total	201,000	201,000

Note numbers may not add due to rounding



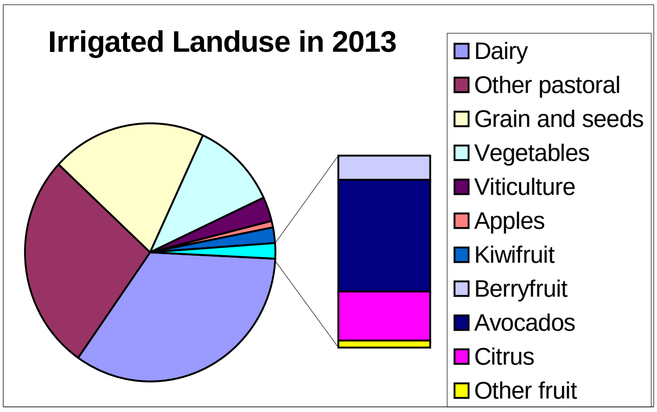
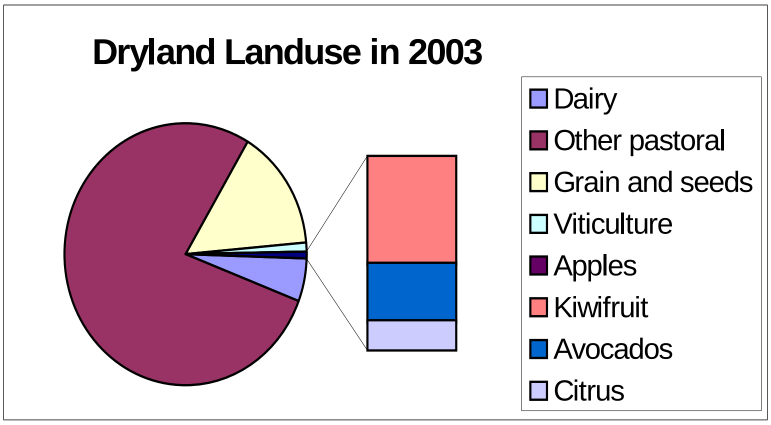
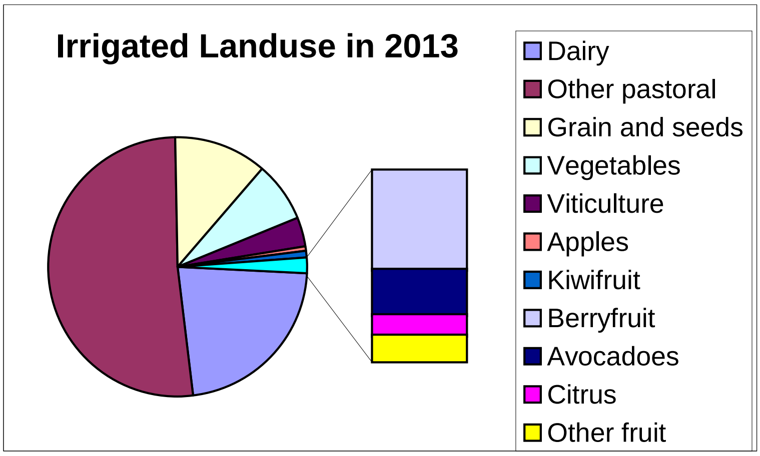


Table 6: Land use assumptions for possible future irrigation (Scenario 2)

Land use	Current Area without irrigation (hectares)	Area in 2013 with irrigation (hectares)
Dairy	25,000	104,600
Other pastoral	365,600	243,300
Grain and seeds	70,400	54,400
Vegetables	-	35,300
Viticulture	4,300	16,200
Apples	500	3,000
Kiwifruit	2,200	4,200
Berryfruit	-	4,700
Avocados	1,200	2,100
Citrus	600	1,000
Other fruit	200	1,200
Total	470,000	470,000





The revenue and costs used are the same as used in the estimate of current value from irrigation, and are shown in Table A3.1 in Appendix 3.

5.3 RESULTS

At 2002/03 prices and production levels, the calculation showed that by 2013 annual farmgate GDP could be increased in the order of an additional $330 million ($1,640/ha) under Scenario

1 and $660 million ($1,400/ha) in Scenario 2. Appendix 3 has these results by region and land use.

These gains do not include flow-on effects from either the use of more inputs or the processing of more product. These impacts are real but difficult to quantify, as the flow-on impacts depend on many factors, for example whether the extra production will be able to be processed with existing capacity, so flow-on effects will be minimal. In others, new industry may be attracted to the locality or indeed be required along with investment for the gains to be realised. More detailed assessment of specific proposals would be required to quantify this.

5.4 DISCUSSION

The calculation of additional farm gate GDP outlined above is conservative because average 2002/03 production levels are used in the calculations. Given the investment that farmers will have made in developing irrigation (assuming no change in current government policy) they will need to generate significantly greater returns than the averages used in these calculations to generate an acceptable return on their investment. However, it is a reality that in the past farmers have tended to accept a very low return on capital particularly relative to the risks they face.

The key benefit of irrigation for economic growth is the greater range of possible land uses that can be undertaken on any particular piece of land. However, the provision of irrigation is only one factor of production, and therefore its presence does not necessarily mean all land use options are therefore possible or viable. In particular, investment in downstream processing and marketing of the produce will determine the success or otherwise of the land use change more than the provision of irrigation.

There is a widely held belief that further development of new higher value land uses, such as process vegetables and vegetable seeds, will be constrained by lack of irrigation availability in the next decade or so. At this point there is believed to be sufficient suitable land, labour and capital available to support expansion of these industries through the substitution of existing land uses (pers com, Stuart Ford, The Agribusiness Group). However, it is reasonable to believe at some point a constriction on irrigation development will constrain further growth of process vegetables and vegetable seeds, industries in which New Zealand has a comparative advantage. Those reasons are;

- Other physical production factors e.g., soils and climate restrict the potential production area of these land uses;
- Crop rotation and isolation requirements restrict the annual utilisation of land for these crops[18] ;
- The efficiency of servicing and processing the output from these land uses considerably improves where production areas are in close proximity to processing plant.

Other factors such as lack of farm management expertise with irrigated production systems, or unwillingness to change land use for some reason, can also serve to effectively constrain production from irrigated land. In a perfect market, these people would, in response to the declining return on investment, sell their farm to someone else who was able to more effectively realise the potential via higher value land uses. However, in reality this change takes time to occur[19]. There are many reasons for this such as stage of life, family history or

[18] For example, high value vegetable seeds can only be grown every tenth year in the same field, and can have isolation requirements of 2km or more. Since irrigation is essential for production of these crops, a large area of irrigated land is necessary.
[19] Although during the last 10 years there appears to have been an acceleration of land use change in the irrigated area of Mid Canterbury.

determination to continue as they have before. Institutional arrangements, such as resource consent requirements, may also create barriers to the smooth operation of market forces, again giving the impression that the availability of irrigated land is constraining production in the short term.

As the results of this study show, there are considerable areas of irrigated land that remain in land uses with less than optimal productive and financial returns. On the face of it, this appears to directly contradict the view that economic growth is constrained by limited irrigation. Theory would suggest that rather than develop more irrigation, the national interest would be better served by altering/changing land uses on land which is currently irrigated or which is within the purview of an existing irrigation scheme. However, when the constraints identified above are considered and accounted for it is apparent that the amount of irrigation available in some locations is in fact the limiting factor.

From the perspective of a company developing a new processing activity in New Zealand, irrigation is essential to ensure a consistent and known level of supply of product through the plant to ensure it is operating at peak efficiency, and to service markets. It is also essential that the price of the raw material is competitive into the future with other sources, both within and outside New Zealand, before the processor would commit to investing in the necessary infrastructure. One way to achieve this is to have a "surplus" of irrigated land available to grow the produce. This will depend on the profitability of other land uses as well as the supply of land and farmer expertise and willingness.

Future irrigation development and land uses will be determined by market led decisions, particularly for individual developments. However, in many locations, individual irrigation development is not practical due to water resource constraints and economies of scale. There are market failures identified in section 9 that prevent community development proceeding. This leads to the widely held view that without increased community irrigation development, further economic growth from large parts of New Zealand will fall short of its optimal level, although it is impossible to say with certainty what the farmers in these areas will produce.

Another important consideration is the state of current production levels without more irrigation development. In some cases, most notably in dryland grain and seed production in Canterbury, the maintenance of current crop contracts increasingly requires irrigation. This is the substitution effect in practice, with buyers of crops traditionally grown without irrigation such as ryegrass seeds, now requiring the farmer to guarantee the amount and quality of the produce. This further adds to the pressure on irrigated land and the potential for economic growth to be constrained. Furthermore, for some of those regions where mainly dryland farms exist, the potential for more diverse farm systems is limited with flow-on consequences for the stability of the community during climatic or market downturns. As described in section 7 on social impacts, there is an impact on the national interest from this phenomenon.

6 Impact of increases in output from irrigated land on product prices

Gross margin calculations generally assume that a change in output has no effect on prices. While for small-scale changes at the individual farm level this may well approximate the truth, the large-scale land use changes generated by irrigation on the national scale are likely to have some measurable effect on output prices.

The impact of the estimated output volume changes on price was assessed using the Lincoln Trade and Environment Model[20] (LTEM) for those products in the irrigation analysis that are incorporated in the model (dairy products, sheepmeat, beef, wool, kiwifruit and apples). The analysis was run separately for the current irrigated area and for Scenario 1 (the "future likely" area). This analysis is indicative at best, and more detailed modelling than was possible in this project would be needed to improve the accuracy of the estimates in the following sections. A discussion of the key factors determining the size and direction of any price impacts is included in Appendix 1, section 4.

6.1 PRICE IMPACTS OF CURRENT IRRIGATED AREA

The LTEM results are presented in Table 7. In this Table, the volume and price changes are those that would occur if the currently irrigated area in New Zealand was in dryland farming systems compared with the current situation. For example, the Table indicates that if there were no irrigation in New Zealand, dairy production would be 9.7% lower and prices paid to New Zealand dairy farmers would be 1.8% higher.

Table 7: Changes in output and prices of key products in the absence of irrigation

Changes in Output and Prices of Key Products in the absence of irrigation		
		% Change
Dairy	producer price	1.83
	quantity	-9.7
Beef	producer price	0.05
	quantity	-3.58
Sheep	producer price	-0.20
	quantity	1.76
Wool	producer price	-0.66
	quantity	2.41
Apples	producer price	0.57
	quantity	-29.84
Kiwifruit	producer price	5.62
	quantity	-10.59

The LTEM results indicate that for most products, the change in output from current irrigation has had very little impact on producer prices. The exception to this is kiwifruit. The estimated percentage decrease in kiwifruit output that would occur if irrigation were not available is substantial. In addition, New Zealand dominates world trade in kiwifruit during the Southern Hemisphere selling season, so a high percentage decrease in kiwifruit production from New

[20] A brief description of the Lincoln Trade and Environment model is included in Appendix 1

Zealand has a very significant impact on the quantity of kiwifruit traded world-wide and therefore the price, assuming other factors remain constant.

If the prices used in the "without irrigation" scenario are adjusted to reflect the price changes indicated by the LTEM, the contribution of irrigation to GDP falls in the order of $30 million (3%) from $920 million to $890 million from the currently irrigated area. That is, the prices for these products would change in the absence of irrigation by the amounts in Table 7, which would have the effect of reducing the contribution of irrigation to GDP by the order of $30 million.

If the boundaries of this analysis are extended beyond the irrigated area to the whole of New Zealand production, the impact on GDP is further reduced. This occurs because the price of *all* milk solids (for example) produced in New Zealand is lower as a result of the increased output of milk solids from the irrigated area. When the price changes in Table 7 are applied across all New Zealand output of LTEM products, the impact of irrigation on GDP at the farmgate is reduced in the order of $100 million, about 11% of the farmgate benefit from the irrigated area.

The products covered by the LTEM contribute 45% of the total contribution of irrigation to GDP. Other products of irrigated agriculture that are not modelled in the LTEM are grain and seeds, vegetables, flowers, other fruit crops, wine and deer. The prices of most of these products tend to be sensitive to changes in output volumes, particularly those supplying the local market. Intuitively it would be expected that the increases in production generated by irrigation would result in a fall in price of these products. However, the impact of a "without irrigation" scenario implies very significant changes in the nature of these sectors, the impacts of which on price are not straightforward to determine. In some cases the crop would not be produced at all, in which case discussions on "what the price would be to New Zealand's producers without irrigation" are unnecessary. The likely impacts by product type are discussed in appendix 1 section 4. In summary, the impact on the price of the products produced under irrigation not able to be modelled using the LTEM are likely to be neutral or positive.

Overall, the changes in output as a result of irrigation development in New Zealand have had a small impact on the price of the major agricultural and horticultural exports from New Zealand. The overall impact of such price changes on the contribution of irrigation to GDP is small but significant, reducing the contribution to the order of $820 million.

6.2 PRICE IMPACTS OF IRRIGATION DEVELOPMENT

In the same way as in the assessment of the *current* farmgate value of irrigation (section 6.1), the impact of the estimated volume changes on price for the *future* scenarios was assessed using the LTEM.

For the LTEM products, the sensitivity of prices to output changes was tested using three different output scenarios. These were scenarios 1 and 2 as described in section 5.1, and a refinement of Scenario 1 in which the conservative area under irrigation by 2013 assumptions were combined with very conservative land use change assumptions (see Table A2.4 in Appendix 2). This provides a conservative, most likely and optimistic view of the possible changes in output by 2013 as a result of irrigation development.

The LTEM results are presented in Table 8. In this Table, the volume and price changes are those that would occur if the irrigated area expanded. For example, the Table indicates that if, by 2013, the irrigated area had expanded to that thought "most likely", dairy production would be 4.33% higher than would be the case if the irrigated area remained static, and prices paid to New Zealand dairy farmers would be 0.81% lower.

Table 8: Impact of irrigation on output and price of key products

		Scenario 1 with Conservative Land use change assumptions % change	Scenario 1 % change most likely	Scenario 2 % change optimistic
Dairy	producer price	-0.49	-0.81	-1.28
	quantity	2.60	4.33	6.90
Beef	producer price	-0.01	-0.01	-0.07
	quantity	0.88	0.82	3.70
Sheep	producer price	0.01	0.11	0.03
	quantity	0.02	0.89	0.01
Wool	producer price	0.23	0.23	0.22
	quantity	0.81	0.80	0.81
Apples	producer price	-0.21	-0.22	-0.39
	quantity	1.91	8.90	15.82
Kiwifruit	producer price	-3.37	-7.53	-7.53
	quantity	6.17	14.43	14.43

Note: In the Table, the change in quantity reflects the change in output as a result of irrigation above what would have been produced in 2010, rather than the change from the current level of production. The 2010 output levels were used as a best approximation to 2013, as the LTEM does not extend to 2013.

The LTEM results indicate that for most products, the change in output from future irrigation is likely to have very little impact on price even at the most optimistic estimates of output change. The price results are reasonably insensitive across the range of output scenarios considered. The exception to this is kiwifruit for the reasons described in 6.1.

Using Scenario 1 (the "likely future" scenario) from Table 8, the price changes result in a fall in the estimated contribution of irrigation to GDP of $7.1 million (or 2.1%). If the boundaries of the analysis are extended beyond the irrigated area, the impact on GDP would be further reduced. When the price changes in Table 7 (most likely column) are applied across all New Zealand's forecast output of LTEM products in 2013, the impact of irrigation on GDP falls by a further $71 million, or a total adjustment to the contribution of irrigation to GDP of $78 million.

The impact of the likely increases in output on the price of non-LTEM crops is exceptionally difficult to determine (appendix 1, section 4). For the purposes of this exercise, a reasonably pessimistic estimate of the likely impact on price was used, based on the impact on apple and kiwifruit prices as indicated by the LTEM results – it was assumed that prices of non-LTEM crops would fall by 5%. Using the most likely future scenario, and incorporating the LTEM price changes and a 5% fall in non-LTEM crop prices, the estimated contribution of future irrigation to GDP falls by $32 million or 10% for the Scenario 1 area of 201,000 ha. This was not extrapolated across all of New Zealand's production of these crops as there are not projections available for all these crops for 2013.

6.3 SUMMARY

Table 9 provides a summary of the results of the impacts of irrigation on prices across all of New Zealand's output. At best, these results are indicative given the assumptions in the LTEM model and those of land use and productivity.

Table 9: Summary of modelling of irrigation production impacts on prices

Irrigated study area (hectares)	Estimated additional farmgate GDP from study area ($m/yr)	Impact of extra production on prices, study area only	Total impact of extra production on prices, across all NZ producers	Net GDP increase due to irrigation	
Currently 475,000 ha	$920	-$30	-$100	$820	
Additional 201,000 ha (Scenario 1)	$330	-$7	-$80	$250	Dairy sheep wool beef kiwifruit & apples only
Additional 201,000 ha (Scenario 1)	$330	-$30	Not estimated	N/A	All products from irrigated land
Additional 470,000 ha (Scenario 2)	$660	Not estimated	Not estimated	N/A	

Table 9 shows that the impacts on New Zealand's current production due to the additional production from irrigated land reduces the net benefits to New Zealand by the order of 10%. Given the degree of variability possible in the assumptions made in this study, this is a relatively minor impact. The impacts of more irrigation development are even less precise and considerably more information and modelling is required to have confidence in the calculation of impacts across the rest of New Zealand's production.

The historical performance of the kiwifruit sector illustrates the complexity of the relationship between increases in the production of New Zealand kiwifruit and price[21]. In recent years, production increases have not always been associated with price falls due to a range of factors such as the production of kiwifruit in competitor countries, exchange rates, fruit quality and (possibly most significantly) the effort put into marketing New Zealand kiwifruit as a premium product. The LTEM takes into account exchange rate and competitor production but cannot incorporate improved marketing strategies. This would also apply in various ways to the other products modelled.

[21] Situation and Outlook for New Zealand Agriculture and Forestry 2003", MAF Policy

7 How does irrigation add to social wellbeing in the national interest?

The social impacts of irrigation are often mentioned in relation to the triple bottom line of economic, environmental and social[22] impacts that underpin sustainable development. However, there is very little information available that is absolute about the social impacts of irrigation specifically, separately from the social changes and adaptations that occur in any community of interest over time. This section does not attempt to incorporate the costs and benefits of social externalities into the analysis of the economic value of irrigation.

Summaries of several key pieces of recent New Zealand research are contained in Appendix 4. Essentially there are some key themes that summarise the impact of irrigation on the national interest in social outcomes. These are;

- Through increased production and intensification there is more employment opportunities created in a community than would otherwise exist.
- Through climate proofing, irrigation prevents much of the economic impact of dry periods from being felt directly in local communities.
- Through land use change, irrigation brings a greater diversity of business activities and therefore greater security to local economies during downturns in any one sector or activity.
- Through general intensification, irrigation brings closer settlement, more farm owners, more employment, and more consistent financial flows through the community, which all build on each other, leading to better services. Optimism and innovation is usually improved as a result.
- Change impacts both positively and negatively within communities depending on the perspective of the observer.
- The national interest is in keeping rural communities stronger than they otherwise would be, in localities where irrigation is the comparative advantage for that community (examples are Culverden and Ashburton).

Irrigation is not the only factor contributing to such impacts. For example, tourism or manufacturing can have similar influences on rural communities. Much depends on the particular location or geographical attributes of the community, which is often the factor that limits the ability of a community to take up other options. For much of the Canterbury Plains, farm-based production is the basis of the communities and likely to remain so in the foreseeable future. Irrigation, rather than tourism or any other economic stimulus, is likely to make a more defining difference to communities in Canterbury than say in Central Otago, where both tourism and irrigation have an (inseparable) impact. Irrigation may well stimulate other economic activities such as tourism, through new recreational activities or just generally higher economic activity and more population.

Land use change is the key to determining impacts from irrigation. Studies and observation suggest that there are waves of land use change once irrigation becomes available, which are accompanied by changes in farm ownership, composition of the workforce, and the demographic profile of the population (McCrostie et al 2003[23]). The same study also noted

[22] Incorporating cultural impacts, sometimes separately referred to in the quadruple bottom line.
[23] Assessing the Social Impacts of Irrigation – A Framework based on New Zealand cases, Taylor N, McClintock W & McCrostie-Little H. June 203, Paper to International Association for Impact Assessment Annual Meeting.

that communities can experience structural and demographic change for an extended period, potentially more than a generation after the irrigation becomes available. Development of irrigation has profound impacts on communities into the future that are difficult to quantify or to attribute to irrigation development alone. Other impacts are via community belief in the future and a “buzz” as new activities are undertaken which feed on itself in much the same way as sporting events, although with arguably more longer lasting effects. Communities that rely on irrigated agriculture believe that without further irrigation development they will decline.

It is also very difficult to separate the impacts of irrigation from improved farming economics. There are no studies that try to do this, but anecdotally much of rural New Zealand’s transformation in some areas is attributed to the development of more irrigation. In fact, much is likely to be due to improved terms of trade of farmers. Notwithstanding this qualification, the above impacts are likely to apply, but are very difficult to quantify. A study comparing two similar regions after 20 years – one with irrigation and one without – showed marked differences in population, income and employment (Ford 2002[24]). The two areas studied were similar in their soils, climate and location compared to large cities, but one has had irrigation of the surrounding farmland for 20 years, while the other remains in predominantly dryland land uses. Compared to the dryland area, the irrigated locality had increased population 16%, had a greater proportion of better paying jobs, more full-time jobs and higher household incomes.

The question of a national interest in the realisation of these benefits will generate debate. The effect will be to have more jobs in various rural areas than would otherwise be the case. However, some of these jobs will be low quality (in terms of the pay and conditions), for example, physical seasonal work (Appendix 4, section 4.5). But for dryland farming areas, irrigation is the most realistic means to grow an inclusive, innovative local economy and therefore to create the opportunities to reduce the inequalities they experience in health, education, employment and housing[25].

[24] Economic and Social Assessment of Community Irrigation Projejcts, Ford S Dec. 2002, MAF Policy Technical Paper 2002/13.
[25] From “Key Government Goals to Guide the Public Sector in Achieving Sustainable Development”

8 How does irrigation impact on environmental outcomes?

It is generally acknowledged that irrigation impacts on environmental, conservation, recreational and cultural values. There are many sources of information on these impacts and this section does not attempt to identify, summarise or quantify them. Therefore the costs and benefits of environmental externalities have not been incorporated into the analysis of the economic value of irrigation. Instead this section attempts to provide an understanding of the mechanisms by which they impact and therefore how they may be mitigated.

The main impact of irrigation application on environmental outcomes is via land use change and the intensification of land use. More intensive farming has a greater risk of adverse environmental impacts, and risks can be accentuated by the physical characteristics of the location, for example the soil types, the proximity of surface water and the slope. Some impacts will be negative and some positive. Most can be influenced significantly by positive management practices, for example cultivation practice, water application efficiency, fertiliser application practices and stocking practices. The risks can be managed but require a much higher level of management input than dryland systems.

Irrigation abstraction has impacts on environmental values associated with building and operating irrigation distribution and application systems, siting, developing and operating storage. There can also be changes to the balance of the ecosystem from which the water is being abstracted.

Irrigation in much of the world occurs in arid or semi-arid continental climates where there is very low natural rainfall. In many of these areas the combination of unsuitable soils and poor drainage has lead to severe problems with soil degradation and salinisation. With the exception of small pockets in Central Otago, these conditions don't exist in New Zealand, so New Zealand is generally not at any risk of major soil degradation from this source.

Loosely the impacts fall into nutrient effects, micro-organism effects and broader conservation effects[26].

8.1 NUTRIENTS

Soluble nutrients (mainly Nitrogen as nitrate ions) from both fertiliser and natural recycling processes in the soils are carried by water percolating through the soil profile or flowing across the ground surface[27]. Irrigation increases the risk of this occurring. Depending on the amount and timing of irrigation, varying amounts of nitrates find their way into underground aquifers or surface rivers and streams. The impact on the concentration of these nutrients is complex and can depend on the form in which the nutrient is supplied, the dilution provided by the waterbody and the balance between various nutrients (most notably nitrogen and phosphorus). It can also take many years before the impact of past nutrient additions become apparent, for example, Lake Taupo.

With irrigation there is generally land use change and/or intensification of use with a concomitant increase in nutrient application and use, and there is potential for higher concentrations of nutrients to occur in waterbodies and catchments that are irrigated than under land uses without irrigation. However, there is also generally a greater ability to

[26] Further information on these impacts can be found in "Effects of Rural Land Use on Water Quality" prepared for the Ministry for the Environment by NIWA, May 2003

[27] MAF Technical Paper 02/17 Nutrient Budgets for Three Mixed Farming Catchments in NZ, shows the impact of intensification of agriculture on nutrient run-off/percolation.

manage both the amount and timing of water applied as irrigation, and the amount of nutrient applied than in natural systems. Mitigation measures are already being used and more are under development, such as decision support systems for more precisely applying fertiliser and water to match the plant demands, soil water monitoring equipment, and improved application technology using centre pivot irrigation.

The mechanisms of nutrient cycling and losses are reasonably well understood, but the relationship of this to nutrient levels in any given stream or groundwater system is not. For example, there appears to be a natural variation in nitrate levels in groundwater that is difficult to isolate from land use effects[28]. Considerable work is continuing to better understand this relationship, as the impact on the environment is of critical importance.

There are also some positive impacts of irrigation that help to reduce nutrient losses. The most common is soil organic matter build up on light stony soils[29] prevalent on the Canterbury Plains. This build up of organic matter improves water-holding capacity, reduces nutrient leaching and reduces soil loss from frost and wind events. The effect is to allow more intensive management of these soils than would otherwise be the case at a similar risk of nutrient or soil loss.

Furthermore, the stability of the farming system over time needs to be considered as an impact of irrigation. For example, during or shortly after droughts, dryland farming systems are often subjected to short term environmentally damaging practices that management would prefer not to have to do (for example, cultivation or mob stocking), just for the farm business to survive. Irrigated farmers are able to minimise such practices because of more reliable production patterns.

8.2 MICRO-ORGANISMS

Irrigation allows pastoral farms to support greater livestock numbers than would otherwise be practical and sustainable for the same level of business risk. Studies completed show a direct link between intensification of livestock farming and greater loads of micro-organisms in water.

The irrigation type and the soil type considerably influence the degree of percolation through the soil into groundwater. These in turn are significantly influenced by irrigation management practices, in the same way as nutrient percolation.

Surface runoff or shallow percolation tends to concentrate the micro-organisms, the impacts of which vary depending on the volume of the receiving water, the type of micro-organism, etc. This is generally not an issue for irrigation of crops, although most arable crop systems have livestock integrated into the system albeit at relatively low stocking rates. However, there are times when stocking is intensive and potential for high micro-organism loadings in receiving waters arises.

Work is underway to quantify the impacts of land use change under irrigation e.g., the Lincoln University dairy farm project co-funded by the MAF Sustainable Farming Fund.

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[28] Presentation by Vince Bidwell, Lincoln Ventures to 2003 Hydrological Society Conference.

[29] Primarily via significantly increased earthworm numbers. Papers: Accumulation of Soil Organic Matter… by Haynes RJ and Williams PH (1992) – Soil Biology and Biochemical Journal vol24 No 3; Effects of Pasture Improvement and Intensive Cultivation on Microbial Biomass, Enzyme Activities and Composition and Size of Earthworm Populations by Fraser PM, Haynes RJ and Williams PH (1994) – Biology and Fertility of Soils vol 17.

8.3 CONSERVATION

Abstraction of water from groundwater or from streams and rivers reduces water flows, which can have a number of impacts on the waterbody concerned e.g., on the habitat provided by the river for flora and fauna, on the recreational value, or on the ability of the waterbody to assimilate waste. Irrigation supply structures and management of water delivery can reduce natural "storm pulses" through rivers – pulses that are often important for stream health (stops silting and removes vegetation). Establishing these structures has short-term environmental impacts and can result in fundamental change to the waterbody.

As well as these negative effects, irrigation can also have positive benefits (apart from the obvious economic ones). e.g., re-charge of groundwater aquifers, runs-off back into streams can maintain more even flows down stream. Dams/reservoirs can also have recreational/ environmental, as well as flood control benefits. As with many complex issues the quest of whether effects are positive or negative are often quite site specific. Costs have been incurred for some communities to ameliorate drainage problems resulting from increased irrigation of surrounding land.

8.4 NET ENVIRONMENTAL RESULT

The net result of these impacts may be positive or negative. Furthermore, what is negative to one group may be positive to another, for example, storage development may impact on some habitats but may result in enhancement of some other water courses. Changes in environmental values due to natural processes that are occurring simultaneously may also further confuse the identification of the impact of irrigation. Information is seldom perfect and different sources of information often cannot be compared directly. As more information becomes available, the concept of environmental bottom lines[30] is being shown to be too simplistic. Rather, it is likely that there are further environmental benefits from maintaining the natural variable flows of the river system.

It is also important to consider the wider picture of how various water systems and irrigation systems interact when considering impacts. While local and regional impacts may focus at the individual catchment level, viewing the system more as one (while recognising the nature of cultural values that may work against this approach) may give an improved outcome. For example, Canterbury has been shown to have more than adequate water for all uses[31], but the water is in the wrong place at the wrong time. Studies in other regions have given similar results.

Storage of excess flows from some major waterbodies in these regions would significantly relieve the environmental pressure that some smaller rivers and groundwater systems are under. Research has helped in an understanding of the close relationship between alluvial groundwater levels on the plains and lowland spring-fed streams (for example, the Avon River in Christchurch) and wetlands. Now that the relationships are becoming better understood, it is evident that there are opportunities to incorporate water abstraction for various uses as part of the active management of environmental, recreational and aesthetic values.

[30] A level above which the environmental benefit from leaving water within the waterbody is outweighed by other values and therefore can be made entirely available for abstraction.
[31] Canterbury Strategic Water Study 2002, MAF Technical Paper 2002/06

9 The national interest in community irrigation scheme development

In some locations, irrigation can be developed by individual investment. For example, in most cases groundwater extraction is best done by individuals obtaining the necessary water consents and drilling a well within their property boundary to extract water. However, in many locations, for a combination of reasons group development is the only feasible option. In most cases this reflects the nature of the available water resource and the fact that the ability to access it is beyond the resources of individuals. Most of the easily accessible water for individuals has already been taken up.

Over time individual developments, whether from ground or surface water, can impact negatively on other values and in total can be an inefficient way to supply irrigation compared to community based schemes. The Canterbury Strategic Water Study provides data that shows that conceptually, storage of excess flood flows from major rivers in Canterbury would be preferable to the current situation of a myriad of groundwater and direct takes that are collectively putting pressure on many of the region's smaller rivers, streams and shallow aquifers.

Market pull can be left to determine the timing of development of individual irrigation opportunities, but the process becomes very much more complicated where collective development is the best option. The need to get everyone involved thinking, acting and committing together to get the scheme built is a very daunting prospect. Only two community schemes have been commissioned in the last 20 years, in part because of these issues. Several sources of market failure have been identified regarding community irrigation scheme development[32], including uncertainty at initial investigation stage, inadequate information on potential benefits and higher than necessary transaction costs. In respect of the national interest, the economic benefits calculated in section 5.3 will not occur without the community schemes proceeding, as individual development possibilities are limited. Therefore the question becomes one of what level and form of public investment is appropriate to ensure these community schemes are built.

Collective development can improve capital and water use efficiencies. Environmental impacts would require careful consideration on a case by case basis, but some of the major concerns about small stream depletion are likely to be reduced by community development instead of individual abstractions.

Development of collective irrigation schemes falters in the area of obtaining collective agreement and commitment from the beneficiaries due to several factors e.g., different individual values, stages of life and risk profiles.

There appears to be a national interest in addressing these failures to facilitate some community irrigation scheme development where the alternative is either no development or a myriad of individual abstractions over time. This is particularly so when it can be shown that such piecemeal development would be inefficient or have a more negative effect on those values that New Zealanders wish to protect in the long term. For example, the collective abstraction and associated energy and stream flow depletion costs from individual groundwater development may be more efficiently served by a community irrigation scheme based on storage of excess flows in rivers under very little abstraction pressure.

[32] Role of Central Government in Community Irrigation Projects, MAF Technical Paper 2002/11

10 Further work

Following on from the investigations from this report, a number of areas of further work have been identified. These are;

- Gathering better data on irrigated land use and productivity over time;
- Gathering data on water use;
- Developing farm models for irrigated and un-irrigated farm types;
- Undertaking further analysis on how the benefits flow through the rest of the economy;
- Gathering data and doing analysis on the influences of supply and demand on products other than the main products produced by the agricultural sector;
- Undertaking further analysis on costs and benefits of irrigation compared to alternative investments and to competing and complementary uses of the water;
- Undertaking research on the degree (if any) to which irrigation capacity is constraining investment in primary sector growth.

11 Conclusion

Irrigation currently contributes a significant economic value to New Zealand, and has the potential to further increase GDP. Prices for most products will be mildly affected by the resulting increases in productivity. In an open trading economy like New Zealand's, other products that are subject to rapid price movements in response to supply and demand do so irrespective of New Zealand's production, although volatility is a key risk for the success of new irrigation development.

There are real impacts of irrigation on social, recreational, cultural and environmental outcomes that need to be optimised with the economic ones described in this report for New Zealand to maximise the national value.

Appendix 1: Methods for evaluating the National benefit from irrigation

1 INTRODUCTION

This section describes alternative methods considered that could be used to calculate GDP and identifies the reasons for choosing the adjusted gross margin method. The adjustments made to the gross margins are also outlined.

2 VALUATION OF WATER[33]

The System of Environmental and Economic Accounts (SEEA) Manual[34] lists three ways that water can be valued:

(i) Using the value of short-term or perpetual water right rentals.
(ii) Comparing farms without irrigation to identical farms with irrigation.
(iii) Using a cost approach: i.e., estimate the value based on the cost of supplying water.

The first method is impractical for New Zealand due to the absence of a market for water rights. The SEEA notes that the third approach is "the least satisfactory from a theoretical point of view". Method two is therefore the most satisfactory approach under New Zealand's institutional framework. The SEEA notes practical problems with this methodology, particularly whether farms without irrigation can be validly compared to farms using irrigation, especially when land use changes as a result. However, provided equivalent farms are compared, the increase in farm value added can still be attributed to irrigation.

3 CALCULATING CONTRIBUTION OF IRRIGATION TO GDP

GDP is a measure of the performance of the New Zealand economy. It is an aggregate measure of the production of goods and services within New Zealand. Many goods and services provided by one producer are purchased by another for use in subsequent production (intermediate consumption) and are therefore deducted from gross output to avoid double counting. For individual producers gross output less intermediate consumption measures their value added and represents that producer's contribution to GDP. For industries, value added equals the value of gross output of each industry less the cost of goods and services used by it in production[35],[36].

In this analysis, two methods were considered for evaluating the contribution of present and future levels of irrigation to GDP. Input-output analysis was one, and the other was a direct assessment of changes in gross output and intermediate consumption using appropriately adjusted gross margins.

[33] MAF acknowledges the assistance of Chase O'Brien of Statistics NZ in compiling this section.
[34] The whole manual is freely available on http;//unstats.un.org/unsd/environment/seea2003.htm
[35] The sum of the value-addeds for each industry is not, however, equal to GDP, the difference being import duties, GST on production, and other taxes on production and imports not allocated to producers. Collectively, these duties and taxes are referred to as 'unallocated taxes.' Unallocated taxes are levied on the purchaser of the taxed commodity and not on the seller, so they are not recorded in the production accounts as a charge against the value of output.
[36] Source: http://www.stats.govt.nz/domino/external/omni/OMNI.NSF/outputs/Quarterly+Gross+Domestic+Product#Design

3.1 Input-output analysis

An input-output (I-O) table is a model of the economy at a particular point in time. It illustrates the interactions and dependencies between industries. It can be used for economic analyses including[37]:

(i) Identifying and measuring the composition and level of economic activity.
(ii) Understanding the inter-relationships between industries.
(ii) Studying the effects of changes in supply and demand throughout the economy including total economic activity (output), household income, value added and employment.
(iii) Analysing the flow of goods and services between industries and final users.
(iv) Providing the basis for the calculation of Gross Domestic Product (GDP).

Consideration was given to using I-O analysis as a tool for estimating the impact of irrigation on GDP, employment and total output from a region and the nation. I-O analysis has been used to evaluate the regional benefits of irrigation. For example, the *Central Plains Water Enhancement: Economic and Social Impact of Proposed Irrigation Schemes report*[38] used I-O to analyse the impact of irrigation in Canterbury in terms of output, employment and value added. Specific multipliers were estimated on the basis of irrigated farm model budgets.

However, the limitations of input-output analysis are well documented.

1. I-O assumes that marginal changes are the same as average ones e.g., assumes that there are no price effects as a result of changed output from a sector. This is clearly inadequate in the case of the large-scale changes in agricultural output generated by current and possibly future expected levels of irrigation, at the national level.

2. I-O assumes that the supply of every input is perfectly elastic i.e., there is sufficient surplus capacity in the economy to deal with any increase in output e.g. processing capacity. This is not the case for many agricultural products, for example dairy factories would need to be expanded if output increased substantially.

3. I-O assumes linear production function technology – it doesn't allow for substitution between factors of production (even if prices change), nor for economies of scale.

4. I-O assumes fixed technology and constant sector purchasing patterns.

The advantage of using I-O analysis in the current study would have been that an estimate of the flow-on effects through the economy of the increase in farm gate value of output and value-added could have been calculated using multipliers. Similarly, increased employment beyond the farmgate could have been estimated. However, robust estimates of the appropriate multipliers are difficult to derive, requiring the development of irrigated and non-irrigated model farm budgets across the range of farming types (and in some cases, regions) covered in the study. This report calculates farm gate values only. An assessment of the flow-on effects of community irrigation schemes in Canterbury may be found in Ford (2002).

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[37] Source: Statistics NZ Regional Input-Output Study July 2003. http://www.stats.govt.nz/domino/external/web/aboutsnz.nsf/874ea91c142289384c2567a80081308e/d6ffed8e292493e2cc256be6000329ab/%24FILE/Regional%20Input-Output%20Study.pdf

[38] Agriculture New Zealand, Butcher Partners Harris Consulting Resource Economists, and Taylor Baines, 2000. Central Plains Water Enhancement: Economic and Social Impact of Proposed Irrigation Schemes Report prepared for Central Plains Water Enhancement Committee, Selwyn District Council and Christchurch City Council.

3.2 Adjusted Gross Margin method

A gross margin is the total revenue associated with a particular production (income) less the costs that clearly vary in direct proportion to the level of production - the direct or variable costs associated with the enterprise. Gross margins are an accepted tool commonly used in the evaluation of farming enterprises. They have been used for the evaluation of the costs and benefits of irrigation[39] in cost benefit analysis. Assessing the change to the gross margin per unit area as a result of irrigation and then scaling this appropriately by the total affected area provides an initial estimate of the GDP change (at the farmgate) likely to occur as a result of irrigation.

This method of adjusted gross margin analysis accords with the SEEA recommendations (section 2) and provides a "best estimate" of the change in GDP generated by irrigation at the farm gate[40]. However, it should be noted that a large number of estimates and assumptions were required to estimate the impact on GDP, and the results should be interpreted with caution. In addition, the increased output from irrigated farms will have different flow-on effects in the wider economy, so the total impact on GDP is likely to be higher than the farm gate impact.

The Gross Margins were adjusted to take account of differences in overheads between land uses, and also for the treatment of wages and salaries to better approximate the way GDP is calculated in the National Accounts.

Overheads

In a standard gross margin calculation, overheads[41] (which typically do not vary significantly as production levels fluctuate) are excluded from the analysis. The underlying assumption is that overheads are similar between the enterprises being compared. However, for this analysis of irrigation GDP contribution, assuming unchanged overheads may result in significant over estimation of the net contribution. The different land uses assumed in the 'with' and 'without' irrigation cases usually have completely different fixed cost structures. Failing to recognise this fact, and adjust overheads accordingly between the with/without cases is therefore likely to produce an upwardly biased GDP estimate.

Therefore in this analysis the value of irrigation, as assessed by the change in gross margin analysis, has been adjusted to reflect expected changes to overheads arising from having the land irrigated. This adjustment has been based on known current overheads and typical fixed costs per enterprise[42] in areas currently irrigated.

Salaries and wages

A potentially even more serious source of error arises from the way "salaries and wages" are treated in GM calculations compared to their treatment in a GDP calculation. In a GM these charges vary in their treatment – sometimes they are treated as overheads and sometimes as direct costs of the enterprise being analysed.

To be consistent with how farmgate GDP is calculated in the National Accounts, a distinction has been made between those wages and salaries within the enterprise that would be part of Intermediate Consumption, and those salaries and wages that would remain within the farmgate GDP calculation.

[39] Economics Division, Ministry of Agriculture and Fisheries, 1977. Cost Benefit Procedures in New Zealand Agriculture.
[40] Pers comm Chase O,Brien and Barry Voice, National Accounts, Statistics New Zealand
[41] Often referred to as fixed costs e.g. communication, insurance, accountancy labour, machinery and legal costs
[42] Derived from MAF's Farm Monitoring Report and Horticulture Monitoring Report 2003.

In converting the GMs into a GDP the following rules have been applied. For dairying, arable farming or pastoral farming and process vegetables all labour has been assumed to be part of the permanent farm staff and wages/salaries paid to these have been added back into the relevant GM's. This adjustment has the effect of raising the farmgate value of GDP of these activities. For apples, kiwifruit and other horticultural crops it is more the norm to employ contractors to carry out operations and for these crops the unadjusted GM has been allowed to stand and GDP calculated as though all wages were part of intermediate consumption. That in turn may well mean that the farmgate GDP impact of increased irrigation of these crops is somewhat understated in the body of the report.

4. THE IMPACT OF INCREASED OUTPUT ON PRICE

Gross margin calculations also generally assume that a change in output has no effect on prices. While for small-scale changes at the individual farm level this may well approximate the truth, the large-scale land use changes generated by irrigation on the national scale are believed to be sufficient to have some measurable effect on output prices. An assessment has been made of the likely magnitude of the price changes using the Lincoln Trade and Environment model as the primary analytical tool, as described in sections 4.7 and 5.4.

The Lincoln Trade and Environment Model (LTEM) is a partial equilibrium (PE) model, used to quantify the price, supply, demand and net trade effects of various policy and non-policy induced shocks. The LTEM is an agricultural multi-country, multi-commodity trade model. There are 18 countries and 19 agricultural commodities included in the model. The model is used to derive the medium to long-term (till 2010) impact in a comparative static fashion, basing the beginning date to 1997. A fuller description of the model may be found in Cagatay and Saunders (2003)[43].

As noted in the text, the products covered by the LTEM contribute 45% of the total contribution of present day irrigation to GDP. Other products of irrigated agriculture that are not modelled in the LTEM are grain and seeds, vegetables, flowers, other fruit crops, wine and deer. The prices of most of these products tend to be sensitive to changes in output volumes, particularly those supplying the local market. Intuitively it would be expected that the increases in production generated by irrigation would result in a fall in price of these products. However, the impact of a “without irrigation” scenario implies very significant changes in the nature of these sectors, the impacts of which on price are not straightforward to determine. In some cases the crop would not be produced at all, in which case discussions on “what the price would be to New Zealand’s producers without irrigation” are unnecessary. The likely impacts by product type are;

- ***Grain and seed crops****:* larger areas of grain crops would be produced under dryland conditions in the “without irrigation” scenario, and depending on the impact on production of natural rainfall each year, production and therefore prices would fluctuate considerably from year to year. Import parity prices apply to grain over time, although it is most likely that grower prices would fall below those assumed in this analysis due to the uncertainty of production and therefore risk to grain purchasers. This would have the effect of increasing the value of irrigation to GDP over that calculated in the body of the

[43] Detail about the LTEM can be found in http://www.mfe.govt.nz/publications/organisms/economic-impact-apr03/appendix7.pdf

report. Furthermore, a significant seed industry would not exist in New Zealand without irrigation.

- ***Process vegetables****:* It is unlikely that this industry would exist on any scale in the absence of irrigation. Processors require an assurance of a reliable supply of raw vegetables before investing in processing plant.

- ***Fresh vegetables and flowers****:* It seems likely that this industry would be very much smaller in the absence of irrigation, focusing on the local market. The industry would be located in those areas with the most reliable rainfall. Production levels and quality, and therefore prices would fluctuate violently from year to year, depending on the pattern and quantity of natural rainfall. Without irrigation, quality and quantity would not be sufficiently reliable to support an export trade (currently substantial for some vegetable crops e.g., onions, squash). Export markets usually yield better prices to the grower than the local market. The overall impact of irrigation on price is therefore impossible to determine and may well be neutral or even positive overall.

- ***Orchard crops****:* As with fresh vegetables, it seems likely that this sector would be focused on the local market in the absence of irrigation. Production levels and quality, and therefore price would tend to be more variable without irrigation. Currently the existence of an export market (made possible by the reliability of output and quality generated by irrigation) prevents oversupply on the local market in most years, minimising the impact on price of the increased output generated by irrigation. In addition, in most years, the export price exceeds the local market price to growers. As with vegetables, overall the impact on price of irrigation may well be neutral or positive.

- ***Wine:*** It is difficult to establish grapevines in the high quality wine producing areas (which are also the driest areas) without irrigation. Output and quality would therefore both be lower in the absence of irrigation. Lower output does not necessarily imply a higher price since New Zealand is a very minor player in world wine trade. Overhead irrigation for frost control is also important in maintaining export production levels of this crop. The overall impact of irrigation on price is therefore ambiguous, and may well be positive.

- ***Deer:*** The change in output of deer products as a result of irrigation is very small and unlikely to have a significant impact on price.

The effect of future expansion of irrigation on prices of non-LTEM crops is even more difficult to determine than the effect of present day irrigation. For crops that are largely dependent on the local fresh market and for which there is little opportunity to develop large-scale export markets (e.g., green leafy vegetables and potatoes) increases in production tend to have a dramatic effect on price. For crops which are produced under contract (e.g., process crops, arable crops) the number of contracts being offered limits the output of these crops. For process vegetables, export markets (and therefore contracts) are growing, but are dependent on exchange rate factors and market development and processing capacity. Some non-LTEM crops are exported (e.g., onions, squash, flowers, deer products, avocados, citrus and wine) and increasing the New Zealand output is likely to require investment in market development, and this could have a measurable impact on price. However, a recent review of the historical trend in New Zealand onion prices at FOB could find no significant relationship between the price and New Zealand production of onions (pers comm Irene Parminter, MAF Policy). World production and trade overwhelms the effect of any increases in New Zealand output, for example, in wine production. The price of some products will change but this change is unrelated to New Zealand's output or irrigation development. In addition, exchange rate factors are a very important factor in the price received.

A complicating factor in assessing the impact of future irrigation-driven increases in output on price is that growers of annual crops are very flexible in the combinations of crops that they choose to grow. If, for example, potatoes are in over supply, growers would switch to another crop which proves more profitable. The crop combinations and gross margins used in the analysis are therefore only indicative of a range of possible crops with similar outcomes. The price impacts of annual crop output increases are therefore likely to be relatively muted compared with increases in perennial crop output, since the latter are less flexible.

A further complicating factor is the increase in flexibility (in terms of crop selection) of the grower/farmer, the degree of management control able to be exerted, and the reliability and quality of output under an irrigated regime. The grower/farmer is therefore able to choose the most profitable product to produce, and to increase the value of the product e.g., by producing at a time of the year when price is highest, or by increasing the quality of the product (for example, through improved fruit size). This upside potential has not by and large been included in the analysis.

In the light of all these considerations, the impact of a 10% fall in price of the non-LTEM crops was modelled when assessing the impact of future irrigation driven increases in output.

5 MEASUREMENT OF THE NATIONAL BENEFIT FROM IRRIGATION

The impact of irrigation on GDP is greater than the national benefit from irrigation. GDP represents the return to producers' labour and capital (including capital tied up in land). The increase in output (and the change of composition of the output) arising from irrigation is dependent on capital investment in irrigation infrastructure on and off the farm, and in on-farm improvements. It is also likely to demand increased labour and managerial input from the owner/operator. The gross margin analysis above captured the off-farm investment in irrigation infrastructure (through the cost of irrigation in the gross margins) but not the on-farm investments, nor the increase in managerial input.

To effectively incorporate these considerations, a cost benefit framework is required. The extra data required for cost benefit analysis is not provided in this progress report. Further work is required to gather and incorporate this information with the gross margin information from this phase.

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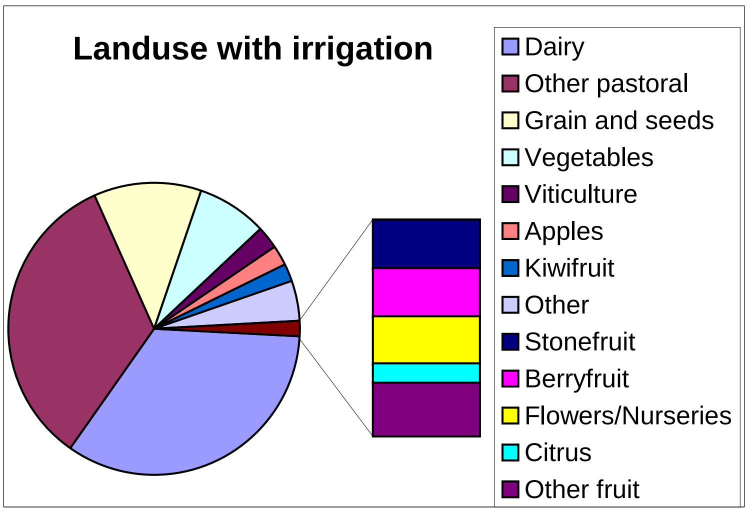
Appendix 2: Assumptions used in irrigation value calculations

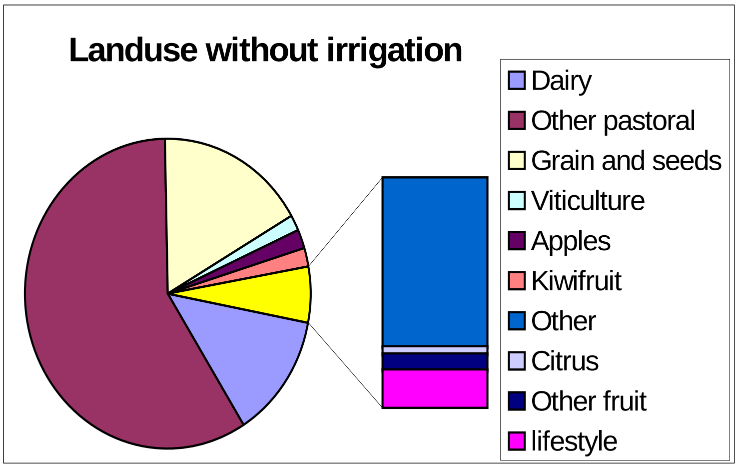
A2.1 LAND USE ASSUMPTIONS FOR CURRENT IRRIGATED AREA

Generally, production from dryland systems is less certain over time, both within and between years. Therefore, while gross margins reflect a difference in farmgate returns that may or may not be a positive return on investment, they do not take into account the fluctuations in returns from year to year or the risk of not achieving the yield in any one year. Therefore, inherent in the following assumptions on land use is a judgement about the likelihood of being able to profitably operate a farm system without irrigation. For example, many arable crops don't require irrigation every year – but without having irrigation available, it is increasingly likely that the farmer will not be able to get a contract to grow the crop, or will otherwise take on considerably more marketing risk.

Table A2.1 Land use assumptions for current irrigated areas

Land use	Area with irrigation (hectares)	Area without irrigation (hectares)
Dairy	161,500	62,000
Other pastoral	159,100	279,500
Grain and seeds	57,300	80,400
Vegetables	37,200	-
Viticulture	11,200	7,400
Apples	10,800	9,600
Kiwifruit	9,400	8,900
Other	20,700	20,700
Stonefruit	2,000	-
Berryfruit	1,900	-
Flowers/Nurseries	1,800	-
Citrus	800	800
Other fruit	2,000	2,000
Lifestyle	-	4,400
Total	475,700	475,700





Specific land use assumptions made in the analysis are:

Northland

- All irrigated dairy, maize and perennial horticulture (kiwifruit, citrus and avocados) would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated annual crops (squash, flowers and fresh vegetables) would be in perennial horticulture predominant in the region (kiwifruit, citrus and avocados) due to relatively lower reliability of production.

Auckland

- All irrigated dairy, kiwifruit, avocados, citrus and grapes would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated annual crops (potatoes, onions, squash and fresh vegetables) would be in dairy farming as best dryland use for that land.

- Other irrigated horticulture (mainly flowers and strawberries) would be in other horticulture common in the area (avocados and kiwifruit).

Waikato

- All irrigated dairy, kiwifruit, avocados and grapes would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated annual crops (potatoes, onions, squash, flowers, berryfruit and fresh vegetables), would be in dairy farming as best dryland use for that land.

Bay of Plenty

- All irrigated dairy, kiwifruit and avocados would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated annual crops (potatoes, onions, squash and flowers) would be in dairy farming as best dryland use for that land.

Gisborne

- Irrigated annual crops (lettuces, squash and sweetcorn) would be in dryland pastoral farming as best dryland use for that land because market demands would not accept the low reliability of production inherent in dryland systems.

- Irrigated kiwifruit and flowers would be in grapes as the best dryland option for that land, as the majority of viticulture in Gisborne operates on dryland.

Hawke's Bay

- Irrigated dairy farms on heavy soils and grapes and apples would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated annual crops (potatoes, onions, peas, sweetcorn, squash and flowers) would be in dryland arable systems as best dryland use for that land. Canterbury gross margins have been used as the dryland scenario in this case.

- Irrigated cereals would be in dryland arable as the best dryland use for that land.

- Irrigated stonefruit and kiwifruit would be in apples as the best dryland use for that land.

Manawatu-Wanganui

- Irrigated dairy farms on heavy soils would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated dairy farms on sandy soils would be in pastoral production as best dryland use for that land.

- Irrigated annual crops (potatoes, lettuces, cabbages and flowers) would be in dairy farming as best dryland use for that land.

Taranaki

- Irrigated dairy farms would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated annual crops (potatoes, fresh vegetables and flowers) would be in dairy farming as best dryland use for that land.

Wellington

- Irrigated dairy farms, apples and grapes on heavy soils would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated fresh vegetable crops and the remaining grape land would be in lifestyle blocks as best dryland use for that land.

- Olives and flowers would be in dryland arable as best dryland use for that land.

Tasman

- Irrigated dairy, pastoral and arable farms, and grapes and some apples would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated annual crops (fresh vegetables and flowers), kiwifruit, berryfruit and most apples would be in a combination of arable, other lower value horticulture and lifestyle blocks as best dryland use for that land.

Marlborough

- Irrigated dairy farms on heavy soils and good rainfall areas, plus irrigated arable farms on good soils, irrigated pastoral farms, and apples would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Grapes on heavy soils will remain in the same land use without irrigation. However, the majority of grapes would be in dryland arable and lifestyle blocks as best dryland use for that land.

- Irrigated dairy and arable farms on lighter soils and process vegetable land would be in dryland pastoral and dryland arable uses as best dryland use for that land.

- Irrigated fresh vegetables and flowers would be in a combination of dryland arable and lifestyle blocks as best dryland use for that land.

Canterbury

- Irrigated dairy farms on heavy soils and pastoral and arable systems on medium and heavy soils would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated dairy farms on medium soils, process and most fresh vegetable crops, and blackcurrants would be in dryland arable systems as best dryland use for that land.

- Irrigated dairy and arable farms on light soils would be in pastoral systems as the best dryland use for that land.

- Irrigated apples, olives, flowers, grapes and some fresh vegetables would be in lifestyle blocks as the best dryland use for that land.

Otago

- Irrigated pasture and arable land would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated arable, vegetable land and flowers would be in dryland arable systems as best dryland use for that land.

- Irrigated dairy, apples, stonefruit and grapes would be in extensive pastoral systems as the best dryland use for that land.

Southland

- Irrigated dairy and arable and land would be in the same land use without irrigation. Irrigation would not alter the land use as the profitability of the land use under dryland is still greater than alternative land uses. However, Gross Margins reflect lower annual production.

- Irrigated vegetable land and flowers would be in dryland crop as best dryland use for that land.

A2.2 LAND USE CHANGE ASSUMPTIONS FOR FUTURE IRRIGATED AREAS

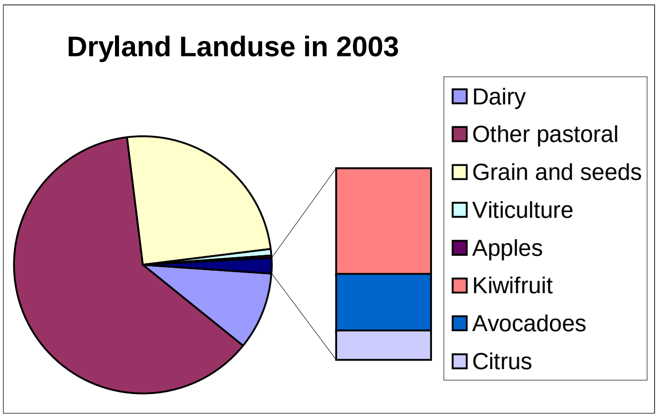
The land use change assumptions for both the future likely irrigation scenario (Scenario 1) and the future possible irrigation scenario (Scenario 2) are based on both individual private irrigation development and identified community schemes currently under investigation.

The land use assumptions for private and community schemes are different. The land use now and in future of land served by private development is based on knowledge of the region and market trends. The land use now and in future of land served by community schemes under investigation is based on a survey of the scheme promoters by MAF Policy regional staff.

Table A2.2 Land use assumptions for likely future irrigation (Scenario 1)

Land use	Current area without irrigation (hectares)	Area in 2013 with irrigation (hectares)
Dairy	19,300	67,900
Other pastoral	125,500	55,200
Grain and seeds	50,000	40,100
Vegetables	-	22,300
Viticulture	2,000	6,100
Apples	300	1,500
Kiwifruit	2,200	4,200
Berryfruit	-	500
Avocados	1,200	2,200
Citrus	600	1,000
Other fruit	-	100
Total	201,000	201,000

Note numbers may not add due to rounding



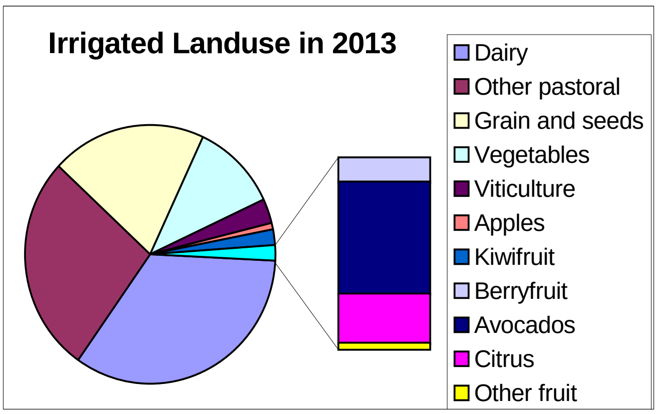
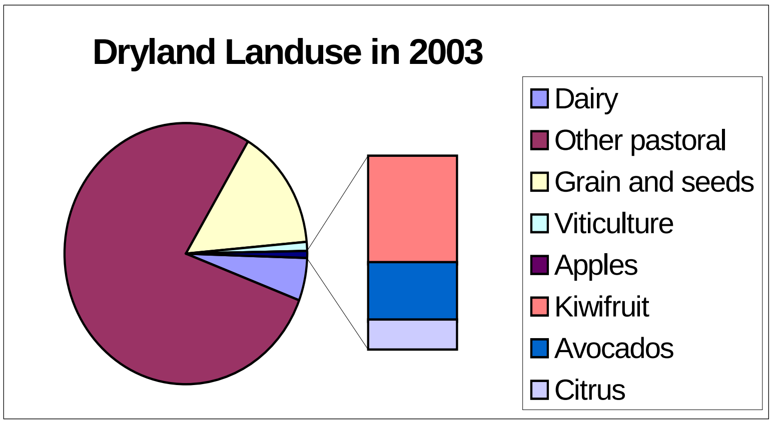


Table A2.3 Land use assumptions for possible future irrigation (Scenario 2)

Land use	Current area without irrigation (hectares)	Area in 2013 with irrigation (hectares)
Dairy	25,000	104,600
Other pastoral	365,600	243,300
Grain and seeds	70,400	54,400
Vegetables	-	35,300
Viticulture	4,300	16,200
Apples	500	3,000
Kiwifruit	2,200	4,200
Berryfruit	-	4,700
Avocados	1,200	2,100
Citrus	600	1,000
Other fruit	200	1,200
Total	470,000	470,000



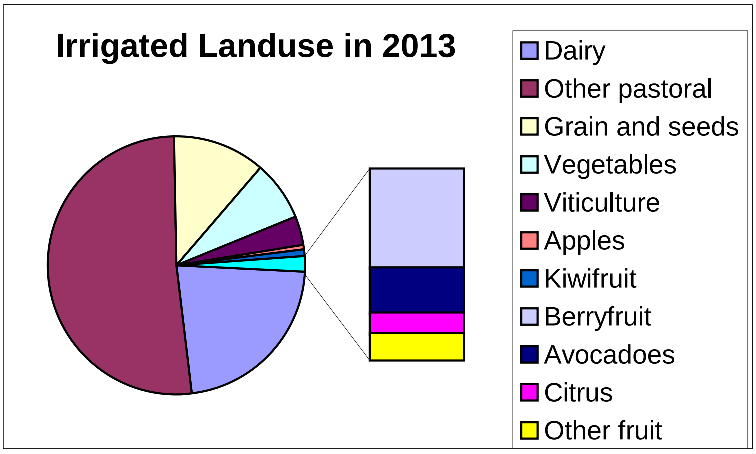


Table A2.4 Land use assumptions for conservative land use scenario (used in section 5.4)

Land use	Current area without irrigation (hectares)	Area in 2013 with irrigation (hectares)
Dairy	19,300	46,200
Other pastoral	125,500	74,500
Grain and seeds	50,000	53,500
Vegetables	-	18,400
Viticulture	2,000	3,500
Apples	300	500
Kiwifruit	2,200	2,900
Berryfruit	-	-
Avocados	1,200	1,000
Citrus	600	800
Other fruit	-	-
Total	201,000	201,000

Note numbers may not add due to rounding

NORTHLAND

Private Development – 5,633ha

- 50% of the new irrigation will be dairy. Fifty percent of this will occur on existing dryland dairy country while the remaining irrigated dairy area will be conversions from dryland sheep and beef.

- 40% of new irrigated area will be kiwifruit, citrus and avocado orchards. Fifty percent of the new irrigation will occur on existing dryland orchards. The remaining 50% will be land use change from sheep and beef.

- 10% of land would be converted from sheep and beef to grow green vegetables.

AUCKLAND

Private development - 506 ha

- All new irrigation will be in intensive horticulture. Apart from the avocados and citrus, which were existing dryland orchards of that variety, all land use change is from dairy.

WAIKATO

Private development – 5,061ha

- 80% of new irrigation will be in intensive horticulture. Apart from some of the kiwifruit and avocados, that were existing dryland orchards, the land use change is from dairy.

- The remaining 20% will be dryland dairy becoming irrigated.

BAY OF PLENTY

Private development – 3,536 ha

- Irrigated area will be kiwifruit and avocados. 50% of the new irrigation would have previously have been dryland kiwifruit and avocado orchards. The remaining land has come from dairy.

GISBORNE

Private development - 795 ha

- All irrigated area to be in squash, sweetcorn and lettuce. Land would previously have been dryland sheep.

HAWKE'S BAY

Private development 10,883 ha

- Hawke's Bay was identified as having 5,000 ha of new irrigation from predicted community scheme. It is believed this 5,000 ha has been double counted, and is accounted for in the 10,883 ha of private development.

- 6,883 ha of the new irrigated area will be dairy. The remaining will be processed crops, arable, apples and grapes. Land use change will be from dryland arable and sheep and beef.

MANAWATU/WANGANUI

Private development – 7,648 ha

- 80% of new irrigation will be dairy farms. The other 20% of new irrigation will be potatoes and green vegetables. The majority of dairy irrigation will be development on existing dryland dairy, the remaining will be land use change from sheep and beef.

WELLINGTON

Private development & future likely – 2,292 ha

- 20% of private development will be in dairy, all of which will be development from existing dairy farms.

- 40% of new irrigation will be sheep and beef, all of which will be development from existing pastoral land use.

- The remaining new irrigation will be intensive horticulture; grapes, apples, kiwifruit, fresh vegetables and processed vegetables. All this will be land use change from sheep and beef.

Possible scheme development - 30,000 ha

- 45% of possible development will be irrigated sheep and beef, all of which will be development from existing pastoral use.

- 25% of possible development will be dairy, from dryland pastoral land use.

- 30% of possible development will be horticultural/arable land use, most of which will be developed from existing horticultural/arable land use, the remaining from dryland sheep and beef.

TASMAN

Private development – 1,204 ha

- 1,000 ha of private development will occur on sheep and beef farms, from existing dryland sheep and beef.
- The remaining will be development of grapes and viticulture. Land use change will be from hops, dryland apples and dryland pastoral.

Likely scheme development – 700 ha

- 100 ha of dryland dairy will be developed into irrigated dairy.
- 300 ha of sheep, beef and deer will be irrigated, this will be development from existing sheep and beef farms.
- The remaining will be apples and grapes, from existing dryland apples and dryland pastoral.

Possible scheme development – 6,000 ha (including the likely 700 ha)

- 40% of the possible new development is in grapes, land use change from dryland pastoral.
- 25% of the possible irrigation development will be pastoral, land use change from dryland pastoral.
- 15% of the possible new development will be apples, some development from existing orchards, but majority land use change from dryland pastoral.
- 10% of new development will be in berryfruit, development from hops and dryland pastoral.
- Remaining area is dairy development, from existing dryland dairy farms, and flowers, from dryland pastoral.

MARLBOROUGH

Private development - 2,423 ha

- 25% of private development will be dairy, some from existing dryland dairy, but majority from dryland pastoral.
- The rest of private development will occur on pastoral, all of which is from existing dryland pastoral.

Likely scheme development – 9,500 ha

- 40% of likely scheme development will be vineyards, majority of which will be developed from existing vineyards, the remaining from dryland pastoral.
- 30% of likely scheme development will be dairy, land use change from dryland sheep and beef.
- 25% of likely scheme development will be pastoral, developed from dryland pastoral.
- Remaining is arable development, majority of which is from dryland pastoral.

Possible scheme development – 13,000 ha (including the likely 9,500 ha)

- 28% of the possible development will be pastoral, from existing pastoral land.
- 40% of the possible development will be vineyards, 50% of which is from existing dryland vineyards, the remainder from dryland pastoral.
- 32% of the possible development will be dairy, land use change largely from dryland pastoral.
- Remaining development is arable, land use change largely from dryland pastoral.

CANTERBURY

Private development – 34,460 ha

- 65% of private development will be on dairy farms.
- 32% will be high value arable and process vegetables, and the remaining is berryfruit and grapes.
- Land use change will be from two-thirds pastoral and one-third dryland arable.

Likely scheme development – 95,000 ha

- 40% of likely development will be arable, largely developed from dryland arable.
- 40% of likely development will be pastoral, developed from dryland pastoral.
- The remaining development is dairy, land use change largely from dryland pastoral.

Possible scheme development – 288,100 ha (including the likely 95,000 ha)

- 65% of possible scheme development will be pastoral, developed from dryland pastoral.
- 20% of possible scheme development will be arable, largely developed from dryland arable.
- 10% will be dairy development, some from existing dairy land, but largely land use change from dryland pastoral.
- Remainder is horticultural development, land use change from dryland pastoral.

OTAGO

Private development 5,510 ha

- Two thirds of irrigation development will be pastoral farming.
- The remaining third is mainly dairy development with a small area in arable and viticulture.
- Land use change is from two-thirds dryland pastoral and one-third dryland arable.

Likely scheme development – 11,400 ha

- 65% of likely development is pastoral, developed from dryland pastoral.
- 25% of development will be dairy, some from existing dairy land, but largely from dryland pastoral.
- The remainder is arable and viticulture. Arable is developed from dryland arable, and viticulture from dryland pastoral.

Possible scheme development – 48,500 ha (including the likely 11,400 ha)

- 60% of development is pastoral, developed from dryland pastoral.
- 25% will be dairy, some developed from existing dairy, but largely from dryland pastoral.
- Remainder is arable and viticulture.

SOUTHLAND

Private development 2,445 ha

- Irrigation development will be from dryland dairy to irrigated dairy.

A 2.5 Gross margins, production levels used

The revenue and gross margins[44] by region used appear in table A2.3, along with the adjustments for irrigation and fixed costs.

Table A2.5 Revenue and costs by land use and region

	Irrigated returns					Dryland Returns				
	Revenue	Costs Direct	Irrigation	Fixed	Adjusted Margin		Revenue	Direct Costs	Fixed Costs	Adjusted Margin
Dairy										
Northland	3,500	1,020	160	545	1,775		2,771	930	545	1,296
Auckland	4,795	1,450	160	545	2,640		3,770	1,330	545	1,895
Waikato	4,795	1,450	160	545	2,640		3,770	1,330	545	1,895
Bay of Plenty	4,795	1,450	160	545	2,640		3,770	1,330	545	1,895
Gisborne										
Hawke's Bay	4,425	1,240	250	545	2,390		3,123	1,180	545	1,398
Taranaki	5,017	1,240	160	545	3,072		3,881	1,560	545	1,776
Manawatu-Wanganui	3,833	1,240	160	545	1,888		3,348	1,120	545	1,683
Wellington	4,632	1,240	200	545	2,647		3,234	1,180	545	1,509
Tasman	5,165	2,075	160	545	2,385		3,955	1,630	545	1,780
Marlborough	5,165	2,075	160	545	2,385		3,585	1,630	545	1,410
West Coast										
Canterbury	4,802	1,610	250	545	2,397		3,012	1,100	545	1,367
Otago	4,425	1,970	200	545	1,710					
Southland	4,425	1,970	120	545	1,790		3,770	1,415	545	1,810
Other Pastoral										
Northland										
Auckland										
Waikato										
Bay of Plenty										
Gisborne							513	142	70	301
Hawke's Bay										
Taranaki										
Manawatu-Wanganui							1140	720	70	350
Wellington										
Tasman	1,422	615	150	70	587		513	170	70	273
Marlborough	1,422	615	150	70	587		513	170	70	273
Canterbury	1,422	360	200	70	792	Intensive	962	262	70	630
						Extensive	513	170	70	273
Otago	1,422	395	60	70	897		513	280	70	163
Southland										

[44] Various sources, including agribusiness consultants operating in the regions throughout New Zealand. For Canterbury, main source was "Profit Plan – Farming for Profit – Crop and Livestock Gross Margins" published by Canterbury Agriculture Ltd in August 2003.

Table A2.5 Summary of Revenue and costs by land use and region (continued)

		Irrigated returns					Dryland Returns			
		Revenue	Direct Costs	Irrigation	Fixed Costs	Adjusted Margin	Revenue	Direct Costs	Fixed Costs	Adjusted Margin
Arable										
Northland		3,080	800	120	300	1,860	2,520	800	300	1,420
Auckland										
Waikato										
Bay of Plenty										
Gisborne										
Hawke's Bay		4,250	1,100	200	300	2,650	1,620	830	300	490
Taranaki										
Manawatu-Wanganui										
Wellington							1,620	830	300	490
Tasman		2,800	810	150	300	1,540	1,690	770	300	620
Marlborough		2,800	810	150	300	1,540	1,690	770	300	620
Canterbury		2,550	950	200	300	1,100	1,690	770	300	620
Otago		2,800	800	120	300	1,580	1,680	540	300	840
Southland		3,300	800	120	300	2,080	2,100	540	300	1,260
Horticulture										
Flowers	High val	325,500	201,000	7,500	20,000	97,000				
	Lower val		27,000		20,000	48,000				
Stonefruit	H'Bay	29,900	17,,300	150	11,100	1,350				
	Otago	30,600	16,250	120	11,100	3,130				
Kiwifruit		31,500	8,760	100	10,500	12,140	26,765	8,790	10,500	7,475
Apples	H'Bay	39,100	16,750	150	11,100	11,100	23,800	11,250	11,100	1,450
	Tasman		14,850	150	11,100	7,900	23,800	10,050	11,100	2,650
Citrus		30,000	3,850	100	4,500	21,550	18,750	3,900	4,500	10,350
Avocados		19,180	4,700	100	4,500	9,880	14,700	4,730	4,500	5,470
Grapes	H'Bay	11,300	2,100	150	5,000	4,050	8,400	2,100	5,000	1,300
	Marl		2,100	90	5,000	12,910	14,700	2,100	5,000	7,600
Potatoes NZ		1,500	7,625	175	300	4,400				
Onions	NI	20,625	10,360	100	300	9,865				
	Cant'y	16,000	6,300	250	300	9,150				
Corn	NI	3,600	1,100	250	300	1,950				
	SI		950	150	300	1,640				
Peas	NI	2,000	900	250	300	550				
	SI		700	200	300	750				

A2.6 Fixed cost assumptions by land use

Fixed costs throughout the land uses are based on administration (communication, insurance, accountancy, legal and consultancy, and sundry) and repairs and maintenance, vehicle and fuel and contract labour. Casual/permanent wages and rates are not included (see Appendix 1 for explanation).

Dairy

- The dairy fixed cost of $545/ha is based on the 2002/03 national average fixed costs sourced from 2003 Farm Monitoring.

Pastoral

- The fixed cost of $70/ha is based on the 2002/03 season national average fixed costs sourced from 2003 Farm Monitoring. Contract shearing wages included in variable costs.

Arable

- The arable fixed cost of $300/ha is based on the 2002/03 Canterbury Arable Cropping Farm Monitoring model. All contract labour prices included in variable costs.

Processed and Fresh Vegetables

- The processed and fresh vegetable fixed cost of $300/ha is based on the Canterbury Arable Cropping model from 2003 Farm Monitoring. All contact labour prices included in variable costs.

Flowers

- Fixed costs for flowers without any labour component is $20,000/ha. There is no contract labour requirement for flowers.

Kiwifruit

- Fixed costs without any labour component are $5,570.
- Labour component is $9,872, of which approximately 50% is contract.
- Total fixed costs are $10,500.
- These costs are sourced from Horticulture Monitoring 2003.

Pipfruit

- Fixed costs without any labour component are $3,869.
- Labour component for Hawke’s Bay and Nelson is $14,412, of which approximately 50% is contract.
- Total fixed costs for Hawke’s Bay and Nelson is $11,100.
- Outlier regions have smaller labour requirement. Their total fixed costs are $8,000.
- These costs are sourced from Pipfruit Monitoring 2003.

Stonefruit

- Stonefruit fixed costs are the same as Pipfruit.

Citrus and Avocados

- Citrus and Avocado crops have fixed costs of $4,500. No labour costs are deducted as industry practice is to employ casual labour directly when required.

Grapes

- Fixed costs without any labour component are $2,862.
- Labour component for Hawke's Bay, Marlborough and Gisborne is $5,870, of which approximately 50% is contract.
- Total fixed costs for Hawke's Bay, Marlborough and Gisborne is rounded to $5,000.
- Outlier regions have smaller labour requirement. Their total fixed costs are $4,000.

Berryfruit

- The berryfruit fixed cost of $4,000/ha is based on the administration cost adjusted from 2003 Pipfruit monitoring.

Olives

- The fixed cost for olives of $3,000 is based on using many of the same costs as per grape production model, scaled down and adjusted where necessary.

Appendix 3: Tables of land use assumptions and results

Table A3.1 Farmgate GDP value of currently irrigated land uses by region

$m (2002/2003)	Irrigated Area (hectares)	Dairy Benefit	Pasture Benefit	Arable Benefit	Hort Benefit	Viticulture Benefit	Undefined Land use	Total	Region $/ha irrigated
Northland	7,000	1.7	0.0	0.0	21.0	0.0	6.0	$28.7	$4,106
Auckland	7,900	-8.8	0.0	0.0	63.1	0.1	0.0	$54.4	$6,883
Waikato	14,500	-3.0	0.0	0.0	58.5	0.2	0.0	$55.7	$3,840
Bay of Plenty	11,400	0.0	0.0	0.0	39.3	0.0	0.0	$39.2	$3,441
Gisborne	5,600	0.0	-1.5	0.0	27.8	-1.0	0.0	$25.3	$4,525
Hawke's Bay	18,100	1.6	0.0	-0.9	83.2	8.3	7.0	$99.2	$5,479
Taranaki	2,900	2.6	0.0	0.0	2.3	0.0	1.1	$6.0	$2,072
Manawatu-Wanganui	8,000	1.2	-0.6	0.0	12.8	0.0	7.6	$21.0	$2,622
Wellington	9,600	6.2	0.0	-0.2	7.3	1.9	6.5	$21.8	$2,268
Tasman	10,000	0.9	0.3	-0.8	32.2	2.3	11.7	$46.6	$4,656
Marlborough	20,200	3.8	0.0	2.9	10.2	54.0	15.0	$85.9	$4,250
Canterbury	287,200	241.9	-21.9	23.2	91.1	0.5	0.0	$334.7	$1,166
Otago	68,900	26.8	29.8	0.6	23.5	1.4	5.4	$87.4	$1,269
Southland	4,100	-0.1	0.0	-0.1	8.7	0.0	4.5	$13.0	$3,173
TOTAL	475,400	$274.6	$6.0	$24.8	$481.0	$67.6	$64.8	$918.9	$1,933

Table A3.2 Farmgate GDP value of Scenario 1 - Future land uses by region

$m (2002/2003)	Irrigated Area (hectares)	Dairy Benefit	Pasture Benefit	Arable Benefit	Hort Benefit	Viticulture Benefit	Undefined Land use	Total	Region $/ha irrigated
Northland	5,633	3.0	-1.2	0.0	29.3	0.0	0.0	$31.2	$5,532
Auckland	2,506	-4.0	0.0	0.0	22.5	0.0	0.0	$18.5	$7,386
Waikato	5,061	-5.7	0.0	0.0	27.4	0.0	0.0	$21.7	$4,289
Bay of Plenty	3,536	-3.4	0.0	0.0	28.2	0.0	0.0	$24.8	$7,016
Gisborne	795	0.0	-0.2	0.0	3.8	0.0	0.0	$3.6	$4,526
Hawke's Bay	10,883	16.4	-4.0	0.1	16.8	9.1	0.0	$38.3	$3,519
Taranaki	0	0.0	0.0	0.0	0.0	0.0	0.0	$0.0	$0
Manawatu-Wanganui	7,648	2.6	-0.9	0.0	7.2	0.0	0.0	$8.9	$1,161
Wellington	2,292	0.4	-0.2	0.0	1.3	2.3	0.0	$3.7	$1,635
Tasman	1,904	0.1	0.4	0.0	1.2	1.9	0.0	$3.5	$1,815
Marlborough	11,923	8.7	-0.3	0.0	0.0	0.0	0.0	$8.4	$702
Canterbury	129,460	94.3	-9.2	29.3	53.3	0.5	0.0	$168.3	$1,300
Otago	16,910	0.0	0.0	-0.8	0.0	0.5	0.0	-$0.3	-$16
Southland	2,445	-0.1	0.0	0.0	0.0	0.0	0.0	-$0.1	-$23
TOTAL	200,996	$112.4	-$15.8	$28.6	$191.0	$14.3	$0.0	$330.5	$1,644

Table A3.3 Farmgate GDP value of Scenario 2 - Future land uses by region

$m (2002/2003)	Irrigated Area (hectares)	Dairy Benefit	Pasture Benefit	Arable Benefit	Hort Benefit	Viticulture Benefit	Undefined land use	Total	Region $/ha irrigated
Northland	5,633	3.0	-1.2	0.0	29.3	0.0	0.0	$31.2	$5,532
Auckland	2,506	-4.0	0.0	0.0	22.5	0.0	0.0	$18.5	$7,386
Waikato	5,061	-5.7	0.0	0.0	27.4	0.0	0.0	$21.7	$4,289
Bay of Plenty	3,536	-3.4	0.0	0.0	28.2	0.0	0.0	$24.8	$7,016
Gisborne	795	0.0	-0.2	0.0	3.8	0.0	0.0	$3.6	$4,526
Hawke's Bay	10,883	16.4	-4.0	0.1	16.8	9.1	0.0	$38.3	$3,519
Taranaki	0	0.0	0.0	0.0	0.0	0.0	0.0	$0.0	$0
Manawatu-Wanganui	7,648	2.6	-0.9	0.0	7.2	0.0	0.0	$8.9	$1,161
Wellington	32,292	22.2	-3.9	3.6	19.1	13.6	0.0	$54.7	$1,692
Tasman	7,205	0.4	-0.6	0.0	15.4	21.9	0.0	$37.0	$5,141
Marlborough	15,423	10.0	-0.3	1.6	0.0	44.4	0.0	$55.8	$3,616
Canterbury	322,560	131.0	29.9	42.0	104.6	4.0	0.0	$311.4	$965
Otago	54,010	22.3	21.9	5.1	0.0	0.9	0.0	$50.2	$929
Southland	2,445	-0.1	0.0	0.0	0.0	0.0	0.0	-$0.1	-$23
TOTAL	469,997	$194.9	$40.5	$52.3	$274.2	$94.0	$0.0	$655.9	$1,396

Appendix 4: Summary of key social impacts studies

A4.1 ASSESSING THE SOCIAL IMPACTS OF IRRIGATION - A FRAMEWORK BASED ON NEW ZEALAND CASES

Paper presented to the International Association for Impact Assessment Annual Meeting, Marrakech. Morocco, 17 – 20 June 2003

Authors: Nick Taylor (Taylor Baines and Associates)
Wayne McClintock (Taylor Baines and Associates)
Heather McCrostie-Little (Ruris)

SUMMARY OF KEY FINDINGS

Throughout recorded history there have repeated examples of how irrigation can transform society as well as land and landscapes. New Zealand is no exception to this rule, with large areas of agricultural land in the east of both main islands being brought into sustained production. These areas have traditionally suffered from severe soil moisture deficits during summer, and periodic droughts.

Assessing the impact of irrigation development is a complex task, as it involves not only changes to the physical landscape and farming practices but also to the social fabric of community life. The social impact of irrigation has generally received less attention in the literature than the physical changes to land use and farming practices; yet the implications can be significant, and far reaching. Taylor (et. al) have expertise in social impact assessment and have focused their attention on developing a framework for assessing the community impacts of irrigation. The framework is based on an analysis of ex-post and ex-ante studies of irrigation projects in New Zealand.

The authors produced a model of the social changes that have occurred in eastern parts of the South Island that have been affected by irrigation. The model shows that there are waves of land use change, which are accompanied by changes in farm ownership, composition of the workforce, and the demographic profile of the population. The model was supported by re-worked Census data (i.e., on labour composition, incomes and age structure), Ministry of Education enrolment data and business data from the New Zealand Business Directory.

The model highlights that the social impacts of irrigation will vary over the life cycle of the project (from initial planning and construction through to the project being an embedded part of the community). This means that communities can experience structural and demographic change for an extended period, potentially more than a generation.

The analysis also highlights that irrigation developments will have implications for water quality, water-based recreation and visual amenity (i.e., the construction of canals and reservoirs). Changes to amenity and recreational values occur gradually with irrigation projects but have significant implications for the social life (cohesion) of communities, and the recreational attraction of areas (i.e., for fresh water anglers).

The overall conclusion of this study is that a social impact framework provides a critical assessment of the costs and benefits of irrigation. It examines irrigation from a community change perspective and it incorporates on-going social monitoring.

A4.2 SOCIAL AND ECONOMIC IMPACTS ASSOCIATED WITH IRRIGATED LAND USE CHANGE

Author: McCrostie-Little and Taylor 2001.

Irrigation Creates Social Change. It changes landscape and has psychological effects on farm families' sense of security.

Irrigation brings land use change and younger or differently skilled farming families. This affects the social structure of the hinterland as well as rural settlements and small towns. It affects work patterns and social interactions.

After a period of Central Government sponsorship, up until the early 1980s, economic conditions and government policy saw regional irrigation schemes sold back to their communities. Local leaders have emerged to take on the planning, funding and commission of existing and new schemes.

The withdrawal of Government funding meant new on-farm development was delayed because of the capital outlay required in buying the scheme. Lack of development money is one of the reasons that farm ownership changes as a direct result of irrigation establishment.

Change of ownership can come in waves.

The population growth in irrigated areas is significant compared to the non-irrigated. Conversion from dryland sheep farming to dairying affects the age structure of the community. In Amuri there was an increase in younger to mid-life males and fewer in the over 60-year-old cohort and the school roll increased by 150%.

Contractors, farm workers and agricultural servicing agencies need to gain new skills and training is not always easily available.

A4.3 ECONOMIC AND SOCIAL ASSESSMENT OF COMMUNITY IRRIGATION PROJECTS

Author: Stuart Ford, MAF Technical Paper 2002/13 December 2002.

This Paper is one of a series, jointly funded by MAF Policy, commissioned to investigate impediments and opportunities for the development of large scale water enhancement projects, in New Zealand, with a primary focus of providing water for community irrigation schemes.

The identification of economic returns from a national, regional and individual viewpoint and the social changes that may occur with community irrigation development was the overall objective of the study. It was identified that there is a need to establish a range of tools to determine parameter values for the assessment of irrigation schemes; it was possible to include them in a framework, but not in one overall benefit assessment. Social impacts do not provide quantitative data suitable for extrapolation into other project areas.

The framework and assessment parameters identified and included were:

- Commercial viability
- Economic contribution
- Social impact

Commercial viability is primarily the interest of farmers and scheme promoters. Central and Local Government and the community or stakeholder interests are mainly interested in the economic and social impacts of any scheme. The social impact grouping was mainly interested in population and occupation trends, employment type, income status and services and community.

Assessment parameter values require the development of economic and social models in order to calculate impacts. The models often are required at a very early stage of the proposal development and therefore need to be based on incomplete or assumed information. These assumptions should be made explicit in the reporting process and include; land use change, timing and location of impacts, basis of analysis and incorporation of change, community bench marking, averaging, and price series.

The parameter values established in this report have been tested and proved in a real scheme analysis on an ex-post basis on the Lower Waitaki Plains Irrigation Scheme. Both economic and social analysis has been compared between the above irrigation development and an area that does not have a community irrigation scheme (based upon development in the Rangitata area).

Within the Social Results, population and occupation trends, employment, income and quantitative analysis are reviewed. It was reported "the standard parameter values could not be considered a substitute for detailed modelling and assessment of individual irrigation scheme impacts they could have a place in determining "in the order of impacts for schemes in their very early investigation stages".

A good bibliography is included with the report.

A4.4 WATER IN NEW ZEALAND AGRICULTURE RESILIENCE AND GROWTH

Authors: Matthew Morgan; Simon Harris; Willie Smith 4 June 2003.

"This study was designed to explore the environmental, economic and social impacts of water use on New Zealand agriculture."

It has been designed to predict the impacts of water use on agriculture in terms of the benefits and costs to the environment, economy and society and as such explores 4 different scenarios covering a range of assumptions to provide different conditions.

Generally:

A A baseline scenario projecting land use in 2021. Assuming current conditions in water management, and demonstrating the impact of agriculture and irrigation under current water management and therefore providing a baseline upon which other possibilities could be assessed.

B Assessing project impacts of water use in 2021 assuming increased standards for receiving ground and surface water quality.

C Addressing institutional, capital and planning barriers. Projects potential irrigation development by 2021 given a strategic approach to water management…with a wide suite of conditions…

D Encompassing all potentially irrigable land that can be developed.

The geographical regions of New Zealand were divided into two groups based on what were viewed as the key drivers of land use change.

(a) Regions where land use change is driven by market forces and constrained by access to water, e.g., East Coast regions, typically drier.

(b) Regions where land use change is driven only by market forces, e.g., conversion to dairying would occur without access to irrigation.

Analysis of the economic impact of irrigation highlights the immense variation between urban and rural with respect to GDP and agricultural (land based) activities. Primary production is an important component of regional economies. Nationally agriculture and forestry amount to approximately 7% GDP, where as Auckland and Wellington is less at 1%-2%. Canterbury and Waikato, for example are more dependent on agriculture with 7% and 14 % respectively. Water policy decisions for agriculture have a disproportionate regional impact.

The social indicators include population structure, farm numbers, number of schools (schools are commonly recognised as the social centre/focal point of interaction in rural New Zealand) and number of sports clubs as measures of community vitality and well being.

It is explained, in the Executive Summary, that the social implications of a change in water management are many, complex and interrelated. As water use increases, the number of farms increases and the rural population will climb; as a result of population increases, community interaction increases, school numbers will grow etc. Productivity of farms will be boosted as will increased spending in rural centres; a rise in the skill base of the community and higher employment levels…a larger labour force.

The social implications of change

Water in any form is fundamental to settlement, social, and economic development in New Zealand. The increased inter-dependence of economic, environmental indicators all contribute directly or indirectly to our understanding of social issues in terms of such factors as the availability of water for domestic supply, irrigation, land use intensification, job creation and minimisation of production risks.

The concept of healthy communities and social wellbeing and their link to water - in particular irrigation - identified four indicators of major significance. The existence of neighbouring farms (the community); the retention of a balanced population structure; the retention of a primary school roll (young family retention and social activities to attract all farm families); and the existence of sports clubs (watch and support).

A4.5 CENTRAL PLAINS WATER ENHANCEMENT: ECONOMIC AND SOCIAL IMPACT OF PROPOSED IRRIGATION SCHEMES

Authors: Agriculture New Zealand, Butcher Partners, Harris Consulting Resource Economists, and Taylor Baines.

An initial study of the potential regional economic benefits of a proposed community irrigation scheme in Canterbury (between the Waimakariri and Rakaia Rivers). The significance of current irrigation to the Canterbury economy, the situation of agriculture in Canterbury and the outlines of the state of irrigation proposals under consideration are reviewed.

Land under irrigation in this region has doubled every decade over the past 50 years. The advent of community irrigation schemes during the 1950s-1970s, representing approximately 30% of the irrigated land area, was dominated by border-dyking. Farmers who have historically taken up water in these schemes have only slowly intensified their livestock farming systems. Significant private irrigation has also been carried out based upon both surface and groundwater sources. The profitability of dairying over the past 15 years has driven land use change and, in some areas, is by far the dominant land use.

The recent trend has been for water to be provided at a much higher cost and for there to be an accelerated trend in intensification and changes of land use to higher return options. Estimates of current land use is estimated to be 34% dairying, 36% other livestock, 27% arable, and the balance 3% horticultural, viticulture and market gardening options.
The four scenarios investigated under possible irrigation development are:

- Changes in intermediate future based on current economics and capacity for cultural and ownership change (likely short term and high productivity).
- An extrapolation of current trends (dairying country).
- A future where the geopolitical climate has changed (fruit and vegetable bowl).
- A very high technology future (biological enterprises).

The scenarios developed show a range of possible impacts arising from irrigation, but it is likely the actual outcome will be a mix of the above, reflecting changes in market conditions over time.

LAND USE (HECTARES) BY SCENARIO

Land use	Present	Likely Short Term	Dairy	Fruit & Vegetable Bowl	Biological Enterprise
Dairy	0	76,089	148,939	76,089	76,089
Dairy Support	0		37,235	0	0
Sheep	118,126	41,218	0	41,218	41,218
Beef	17,908	15,638	0	15,638	15,638
Deer	7,903	19,232	0	19,232	19,232
Arable	45,086	32,819	0	0	15,083
Process Crop	4,214	6,253	6,253	14,087	12,583
Horticulture	0	1,177	0	26,161	12,583
TOTAL	192,427	192,427	192,427	192,427	192,427

Farm budgets were developed for each land use and incorporated into models to estimate multipliers and regional impacts of irrigation development (including flow-on) for farm businesses including, labour and employment, expenditure, and social impacts, all of which have been reviewed.

Social Issues

The Social impacts of irrigation are addressed in Chapter 7: "Water can transform the land. Its introduction into farming systems through irrigation therefore has distinct social impacts for farm families and rural communities".

The introduction of water results in land use changes and all the social disruptions that follow. Many existing traditional farm families adopt irrigation and its opportunities; however many “new” families are attracted to the district for the challenges and opportunities. Communities can initially be disrupted and even disestablished by these changes. The “local families” who remain, it is suggested, remain as a “foci” validating new land uses and acting as “social anchors” around which the new emerging community will gather.

Many social benefits will occur because of irrigation and the associated changes, both at district and regional levels through the development of infrastructure, services and processing industries. Management of the impacts could include:

- Infrastructure and resource planning, including housing;
- Manpower and training strategies;
- Small business development;
- Research and development and advisory services;
- Social service planning and co-ordination;
- Monitoring of social changes and needs.

A desk-top review of likely social changes, based upon comparative cases mainly throughout Otago and Canterbury, since 1970s, by the author who has been directly involved in many of these studies, is presented.

It is explained that "the social consequence of irrigation will extend beyond demographic changes in land use, to include social consequences for farming systems and for wider rural communities. Indeed the net social benefit arising from new irrigation developments will depend on the extent that the rural communities are actively involved in capturing the opportunities presented by irrigation".