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REVIEW OF THE ECONOMICS OF THE COMMUNITY SURFACE DRAINAGE PROGRAM IN THE SHEPPARTON IRRIGATION REGION[1]

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1. INTRODUCTION

The Community Surface Drainage (CSD) Program is a key component of the regional strategy to manage the problem of salinity and rising watertables in the Northern Irrigation Region (NIR). It is being implemented through the various salinity management plans. It aims to provide a cost-effective and environmentally sensitive method of enhancing existing regional drainage while encouraging landholders to act cooperatively with the state, local and commonwealth governments to tackle salinity and waterlogging problems.

The implementation of CSD Program in the Shepparton Irrigation Region (SIR) started in 1990, providing financial, technical and operational assistance to landholder groups to survey and design, construct and fence off the drains. The costs are shared between the federal, state and local governments and landholders based on the 'beneficiary pays principle'.

The funding for the Program came from the State Government and the Federal Government through the Murray-Darling Basin Commission (MDBC). Technical information is provided by staff from the Department of Natural Resources and Environment (DNRE), Goulburn- Murray Water (G-MW) and Sinclair Knight Mertz (SKM) Consulting Engineers. DNRE staff also facilitate landholder groups.

[1] This paper is based on a study to evaluate the economics of the CSD Program in the Northern Irrigation Region of Victoria and presented the review of the economics of the CSD Program in the Shepparton Irrigation Region (SIR) covering the period from 1990-91 to 1996-97.

This paper may be of assistance to you but the State of Victoria and its employees do not guarantee that it is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this paper.

Rationale of the Study

The progress of the salinity management plans, the Shepparton Irrigation Region Land and Water Salinity Management Plan (SIRLWSMP) in particular is monitored annually to ensure that its further implementation meets the investment criteria of all cost sharing parties. The annual reporting system, however, only covers the physical output and costs of its different components and does not evaluate the Plan's economic impact to the catchment.

A study, therefore, was initiated in response to the need to determine the economic impact of the CSD Program in NIR after more than five years of implementation. It aimed to determine whether improvements in productivity are being achieved at a low cost and to identify the physical changes in the catchment as a result of the CSD.

Specifically, the study aimed to;

a. develop a framework to evaluate both individual schemes and the program as a whole,
b. estimate the economic value of the CSD Program from 1990/91 to 1996/97,
c. generate information on four CSD Schemes across the Northern Irrigation Region (NIR) and
d. identify information gaps to direct future areas of research.

2. RESEARCH METHOD

The study for the SIR had two analytical components: analyses of the CSD Program as a whole and the two case study schemes. The CSD Program evaluation was done in two parts due to the requirement for information to be generated in 1996. However, the program costs for this period was compared to the 1990/91 to 1996/97 to show the changes in the level of government and community contribution and the break down of costs.

2.1 Two-part evaluation of the CSD Program

The **preliminary evaluation** was undertaken to generate information in 1996. It covered the period from 1990/91 to 1994/95. The results of the evaluation are not included in this paper.

A more rigorous analysis referred to as **final evaluation** covered the period from 1990/91 to 1996/97. It incorporated the findings from the case studies and studies on pasture losses due to waterlogging and flooding. The updated gross margins per hectare of dairying, mixed farming and were also used.

2.2 Data Collection

Data sets were collected from various sources such MDBC, G-MW, CSD Program Coordinator and CSD Officers (CSDOs), Geographical Information System (GIS) Group,

Economists and Whole Farm Planning Officers (WFPOs). The data sets and assumptions used in the analysis of the CSD Program are listed in Attachment 1.

The agricultural benefits were estimated using average regional gross margins per effective hectare for the different enterprises. It was assumed that there is a lag time before full benefits are received:

	Benefits to Dairy/Mixed farms
Year 0	construction phase
Year 1	50%
Year 2	75%
Year 3	100%

2.3 Data Analysis

The data sets were analysed using the MDBC's Drainage Evaluation Model (DEM).

2.3.1 The Drainage Evaluation Model

The Model was developed by MDBC specifically to accommodate the differences in the engineering, environmental and economic aspects of drainage projects. This allows easy comparison between drainage projects funded by MDBC.

It evaluates the 'with' and 'without' project scenarios to quantify the changes occurring in the catchment. It calculates the impact of surface drainage in minimising or preventing agricultural losses due to waterlogging, flooding and salinity.

The Model is an Excel Worksheet and the calculations are macro-driven. The worksheet has 14 linked sheets as follows;

1. Agricultural production with the project,
2. Agricultural production without the project,
3. Agricultural salinity losses,
4. Waterlogging and flooding losses,
5. Drainage effectiveness,
6. Drainage and landforming with project,
7. Drainage and landforming without project,
8. Drainage and landforming capital and O & M costs,
9. Road benefits,
10. Downstream costs,
11. Re-use benefits,
12. Summary cash flow,
13. Results and summary,
14. Data input summary.

It undertakes an economic evaluation in terms of Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost Ratio (BCR) using the MDBC recommended discount rate of 5 per cent over 50 years.

Sensitivity tests of the variables used such as discount rate, land use change, salinity, waterlogging and flooding were performed to determine their effects on the economics of the CSD Program.

2.3.2 Modification of the Drainage Evaluation Model

The DEM is currently set up to carry out *ex-ante* analysis where annual data are interpolated from the data for Years 1, 10, 20, 30, 40 and 50 using Excel macros.

The data were modified to incorporate the actual data in the analysis. This involved indexing the 1990/91 to 1996/97 nominal value of gross margins and costs to 1996/97 values using Consumer Price Index (CPI). The indexed data, representing Years 1 to 7, were then manually inputted. For Years 8 to 50, the Model's calculated values were used.

While the Model can calculate the benefits due to land use change, it does not provide input cells for costs associated with changing the land use. The costs were establishment cost of permanent pasture, purchase of additional livestock and construction of farm drains. This limitation was corrected by modifying the "Other benefits and costs" category and adding the calculated NPV to the capital cost category.

2.4 Limitations of the Study

The results from the Program evaluation were limited by the data available. Except for the total capital cost of the drains, no other primary data were collected for the whole of the SIR. This study, however, gave an indication of the economic value of the CSD Program and also a good indication of where data were lacking.

This type of work was also limited by the variability of management that occurred on farms as the production increase may have been a result of drainage and/or some other management change.

The social aspects of the CSD Program, such as group cohesiveness or how well the extension program is functioning, were not covered by the study.

For this study, the benefits due to land use change included;

- increased stocking rate,
- increased hay production and,
- changes in enterprise or variety or type of crops or fruit trees planted resulting to an increase in gross margin per hectare.

The terms 'increased productivity, stocking rate and hay production' were used to denote benefits due to land use change and *vice-versa*.

The following benefits were not measured;

- enhanced amenity,
- environmental benefits such as enhancement of wetlands and planting of trees,
- roads not flooded - social benefits,
- improved safety on roads,
- improved quality of life,
- health risks reduced both human and animal,
- ease of management,
- reduced risk of being flooded, the opportunity to change enterprises and
- increased land values.

The following costs were not measured;

- nutrients (not currently included in the DEM)
- other costs to the farmers such as value of the land taken up by drains, and maintenance track (between nine and 12 metres), G-MW drainage rates and time spent during the consultation phase.

The evaluation only covered the economics of the drains from the State's point of view and did not include the effects of the drain construction on the farm's financial situation or over-all profitability.

The use of regional averages may have under or over valued the benefits and costs.

3. THE SHEPPARTON IRRIGATION REGION

The Shepparton Irrigation Region covers about 500,000 hectares and has about 487,000 hectares of farm land (Figure 1). Of that area, about 427,000 hectares are suitable for irrigation in the irrigation areas of Murray Valley, Shepparton, Central Goulburn and Rochester (SIRLWSMP, 1987 pp 6-8).

In 1996/97, there were 7,621 properties covering a total of 315,000 hectares[2] which were irrigated from the Goulburn and Murray Irrigation Systems (Table 1). Dairy farms accounted for 37 per cent of the total farms; nine per cent were horticultural properties; 12 per cent were cropping and grazing farms; and, 42 per cent were grazing properties. This mix of enterprise reflected the land use in the Region. About 88 per cent of the irrigated areas was sown to pasture; five per cent was crops; five per cent was horticulture with the remainder being lucerne and irrigated woodlots.

Table 1 Lands under irrigated culture, Shepparton Irrigation Region, 1996/97

[2] This is the total for Shepparton, Central Goulburn, Rochester, Broken River and Broken Creek Diversions, Goulburn River Diversions and Murray Valley.

Area of holdings (ha)	442,874	
Sample area (ha)	423,272	
Farm types (No. of farms)		% of total
Dairy	2,801	37%
Horticulture	712	9%
Cropping & grazing	938	12%
Grazing	3,170	42%
TOTAL	7,621	100%
Land use (ha)		
Perennial pasture	163,627	52%
Annual pasture	112,416	36%
Lucerne	6,067	2%
Crops	16,380	5%
Horticulture	15,738	5%
Irrigated woodlots	331	< 1%
TOTAL	314,559	100%

Rounding-off errors may occur
Source: Goulburn-Murray Water Irrigated Farm Census, 1997

4. RESULTS

Community surface drains (CSDs) which are generally smaller than arterial drains[3] are designed to serve smaller sub-catchments. These drains are constructed, operated and maintained by a group of landholders with government assistance. The design standard for CSDs is for a 1:2 year rainfall event and conforms with G-MW Guidelines (SIRLWSM Strategic Plan, 1995 p.60).

For the period 1990/91 to 1996/97, a total of 384 kilometres of CSDs were constructed, servicing about 38,300 hectares (Table 2).

[3] Arterial drains are public drains which are constructed, operated and maintained by Goulburn-Murray Water. The design standard is for 1:10 year rainfall event.

A 1:10 year rainfall event is a rainfall event of 75 mm in 24 hours being removed in five days. A 1:2 year rainfall event is a rainfall event of 50 mm in 24 hours being removed in five days.

Figure 1

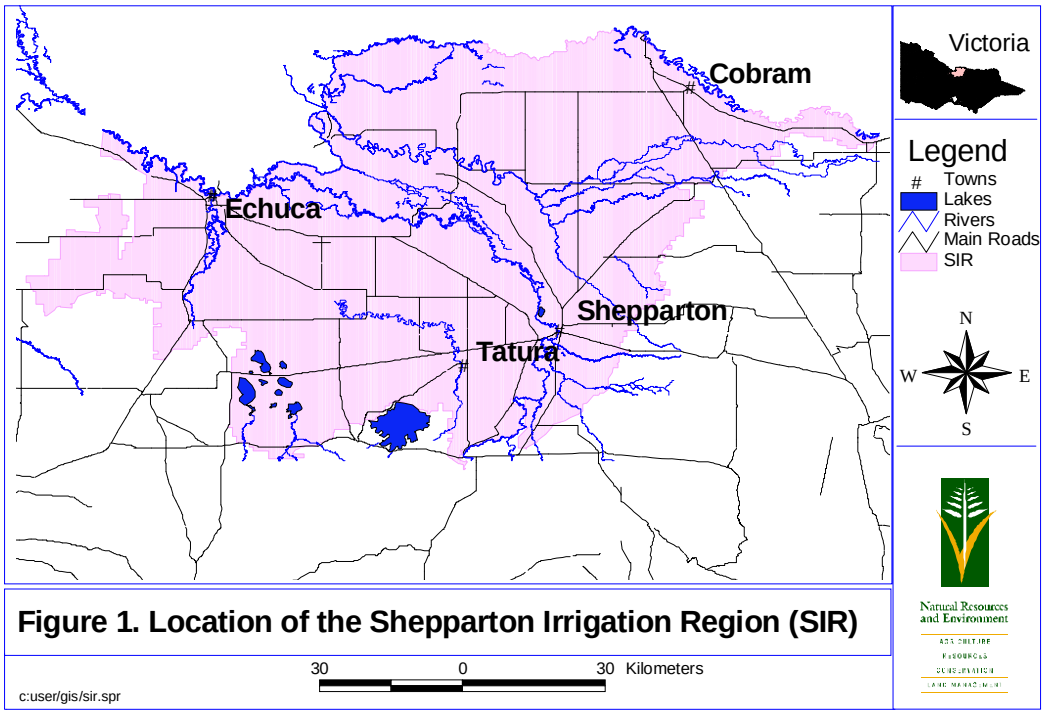

Figure 1. Location of the Shepparton Irrigation Region (SIR)

Table 2 Length of drains constructed and area drained, Shepparton Irrigation Region, 1990/91 - 1996/97

Year	length (km)	area serviced (ha)
1990/91	30	3,120
1991/92	12	1,248
1992/93	54	5,616
1993/94	48	4,992
1994/95	66	6,864
1995/96	67	8,133
1996/97	108	8,316
Total	**385**	**38,289**

Sources: F. Johnson, CSD Program Coordinator, DNRE Tatura
SIRLWSMP Annual Reports
Rod Taylor, Project Officer for Rochester Irrigation Area, DNRE Echuca

Table 2 shows that the length of drains constructed in the two-year period 1995/96 to 1996/97 was more than 80 per cent of the length of drains constructed in the five-year period 1990/91 to 1994/95. This was due to increased funding (refer to Table 5), improved skills of the extension staff and the community's on-going commitment to the Program.

4.1 Land Use

Of the 38,300 hectares drained in the Shepparton Irrigation Region, 60 per cent were dairy farms, 35 per cent were mixed farms and five per cent were horticultural farms (Table 3).

Table 3 Land use, Shepparton Irrigation Region, 1996/97

	Area (ha)	%
Dairying	22,973	65%
Mixed farming	13,401	35%
Horticulture	1,914	5%
Total	38,288	100%

Source: F. Johnson, CSD Program Coordinator, DNRE Tatura

4.2 Flooding and Waterlogging

Annually, about five per cent of farm land in the Shepparton Irrigation Region is subject to flooding (DEM User Manual). This may lead to gross margin losses of 12.5 per cent on dairy and mixed farms and 100 per cent on horticulture (Maher and Shaw, 1996).

About 53 per cent of the soils in the Shepparton Irrigation Region are prone to waterlogging (DEM User Manual, pp. 18-20). Waterlogging may cause gross margin losses of up to 6.25 per cent in dairy and 25 per cent on mixed farms (Maher, 1997). There are no water-logging losses on horticultural plantings because they are generally located on lighter soil types that are not prone to waterlogging (MDBC Drainage Technical Report No. 2, p. 48)

4.3 Cost - Benefit Analysis

Projects with a benefit-cost ratio of at least 1:1 and a positive net present value at 5 per cent over 50 years are considered economically attractive.

Benefits

The three main categories of the benefits of community drains are agriculture, re-use of drainage water and road benefits. The benefits to agriculture include reduction in salinity, waterlogging and flooding losses, and benefits from land use change. Table 4 shows the land use change benefits experienced by the different enterprises following the construction of CSDs.

Table 4 Average regional gross margin, Shepparton Irrigation Region

	Gross margin ($/eff. ha)	
	with drains	without drains
Dairying	$1,429	$1,275
Mixed farming	$263	$254
Horticulture	$3,731	$3,731

Sources: J. Branson, Farm Management Economist, DNRE Echuca
O. Montecillo, Farm Management Economist, DNRE Echuca
L. Mason, Farm Management Economist, DNRE Kerang

Costs

The total capital investment in the Community Surface Drainage Program in the SIR between 1990/91 and 1996/97 reached $17 million (in nominal dollars). In 1996/97 dollars (using CPI as an index) this was equivalent to $17.9 million (Table 5).

The community contributed more than half the total expenditure and the balance was contributed by the government. The community's total contribution to the Program would have been much higher if the income from land taken up by drains, G-MW drainage rates and the farmers' time spent during consultations were taken into account.

Table 5 Total expenditure on CSD Program, Shepparton Irrigation Region, 1990/91 to 1996/97

Year	Government ($'000 nominal)	Community ($'000 nominal)	Total ($'000 nominal)	CPI inflated ($'000)
1990/91	$ 908.2	$ 601.3	$ 1,509.5	$ 1,719.3
1991/92	$ 628.3	$ 278.1	$ 906.4	$ 984.4
1992/93	$ 1,052.4	$ 1,269.5	$ 2,321.9	$ 2,475.2
1993/94	$ 1,053.6	$ 1,217.1	$ 2,270.7	$ 2,395.6
1994/95	$ 1,401.6	$ 1,731.8	$ 3,133.4	$ 3,243.0
1995/96	$ 1,463.7	$ 2,018.7	$ 3,482.4	$ 3,667.0
1996/97	$ 1,435.1	$ 1,950.2	$ 3,385.3	$ 3,419.1
Total	$ 7,942.9	$ 9,066.7	$ 17,009.6	$ 17,903.6

Rounding-off errors may occur.
Sources: F. Johnson, CSD Program Coordinator, DNRE Tatura
SIRLWSMP Annual Reports
Rod Taylor, Project Officer for Rochester Irrigation Area, DNRE Echuca

The emphasis during the first few years of the program was in institution building such as development of technical and operational guidelines and procedures. The construction costs of the drains accounted for 22 per cent of the total expenditure for the period 1990/91 to 1994/95 (Table 6). Its share in the total program expenditure increased to 28 per cent for the period 1990/91 to 1996/97.

Table 6 Breakdown of total costs, CSD Program, Shepparton Irrigation Region, 1990/91 to 1994/95 and 1990/91 to 1996/97 (in $'000 nominal dollars)

	Initial evaluation (1990/91 to 1994/95)		Final evaluation (1990/91 to 1996/97)	
	$'000	%	$'000	%
Feasibility study	$ 547.4	5%	$ 547.4	3%
Survey & design	$ 1,420.2	14%	$ 1,929.3	11%
Construction	$ 2,231.4	22%	$ 4,698.3	28%
Project management	$ 66.7	1%	$ 177.8	1%
Government support	$ 2,097.6	21%	$ 3,204.7	19%
Farm investment	$ 3,596.0	35%	$ 6,037.9	35%
Operating & maintenance	$ 182.7	2%	$ 414.2	2%
Total	$ 10,142.0	100%	$ 17,009.6	100%

Rounding-off errors may occur.
Sources: F. Johnson, CSD Program Coordinator, DNRE Tatura
SIRLWSMP Annual Reports
Rod Taylor, Project Officer for Rochester Irrigation Area, DNRE Echuca

Benefit-cost ratio

The discounted value of the benefits of community drains in the Region was about $93.2 million (Table 7).

Table 7 Discounted value of benefits of the CSD Scheme, Shepparton Irrigation Region (5% over 50 years)

	Benefits	($'000)	% of total
Agriculture	Salinity	$4,290	
	Waterlogging	$7,354	
	Flooding	$5,052	
	Land use change	$49,804	
	Sub-total, agriculture	$66,450	71%
Re-use		$3,607	4%
Roads		$23,092	25%
TOTAL		$93,199	100%

Rounding-off errors may occur.

The agricultural benefits accounted for about 71 per cent of the benefits. Re-use benefits from the CSD Program comprised of four per cent of the total benefits with road benefits making up 25 per cent of the total benefits.

The following costs were included in the analysis;

- capital cost of CSD (Table 6),
- farm investment (landforming, re-use system, purchase of livestock, pasture establishment),
- operating and maintenance cost of drains, and
- downstream cost.

At 5 per cent discount rate over 50 years, the total cost of the Program was $30.3 million (Table 8).

Table 8 Discounted value of the cost of the CSD Program, Shepparton Irrigation Region

	Discounted value ($'000)
Capital cost	$28,179
Operating and maintenance cost	$2,083
Downstream cost	$18
Total	$30,280

The Net Present Value (NPV) of the CSD Program was $62.9 million, about $163,600 per km of drain and $1,600 per hectare drained. It was much higher than the G-MW's calculation of $79.9 million for the whole of the SIR which is equivalent to $279 per hectare drained or $38,000 per km of drains (SIRLWSMP Strategic Plan, 1995, p.65).

The BCR was 3.1 compared to the 1994 MDBC estimate of 2.1 and the 1995 G-MW estimate of 1.7 (MDBC, Drainage program Technical Report No. 2 p. 56 and SIRLWSMP Strategic Plan, 1995, p.65).

The difference in the NPV and BCR was mainly due to the exclusion of land use change benefits in the MDBC and G-MW estimates.

4.4 Sensitivity Analysis

The agricultural benefits were tested to determine the sensitivity of the economic indicators (BCR and NPV) to the changes in these variables. The results are shown in Table 9.

Table 9 Results of sensitivity analysis, CSD Program

	NPV ($'000)	IRR
Base scenario	$62,918	3.1
Discount rate (8%)	$30,780	2.1
No salinity benefits	$58,628	2.9
No waterlogging benefits	$55,565	2.8
No flooding benefits	$57,814	2.9
No land use change benefits	$15,151	1.6

Discount rate

Using a discount rate of 8 per cent over 50 years, the benefit cost ratio was 2.1:1 with a NPV of $30.8 million. This was equivalent to $80,00 per km of drains or $800 per hectare drained. The effect of a higher discount rate was significant but the overall CSD Program was still attractive from the economic point of view.

Salinity

The effect of 'No Salinity Benefit' Scenario on the economics of the CSD Program in the Shepparton Irrigation Region was not significant. The BCR would decline from 3.1 to 2.9 at 5 per cent discount rate over 50 years if there were no salinity benefits. The NPV was $58.6 million.

Waterlogging and Flooding

Removing the waterlogging benefits from the equation would reduce the BCR from 3.1 to 2.8 which was still economically acceptable. The NPV decreased from $62.9 million to $55.6 million.

Without flooding benefits, the BCR of the CSD Program would decline to 2.9 and the NPV was $57.8 million.

Land Use

Without change in land use, the NPV was $15.2 million with a BCR of 1.6 at 5 per cent discount rate over 50 years. Although the BCR was cut by almost 50 per cent, the Program was still economically acceptable and can pay for itself.

Conclusion

The sensitivity tests undertaken for the above variables showed that the CSD Program was viable.

4.5 Discussion

The benefits of the CSD Program due to land use change was about 60 per cent of the total benefits. This can be regarded as a private benefit and may have implications to the Program's cost sharing arrangement. Although these benefits can be considered private, the landholders faced private risk to achieve them. Furthermore, there are other landholder costs and government benefits which were not included in the analysis such as;

- time spent by landholders during consultation and construction of the schemes,
- land taken up by the drains,
- additional G-MW drainage rates the farmers were paying after the drains were constructed,
- environmental benefits, and
- social benefits.

From the Shires' perspective, the benefits of reduced road maintenance should at least match their contributions to the CSD Program. At present there is no system in place to do a cost-benefit analysis due to lack of data on the pre-drain road maintenance cost. As it takes at least two years between the initial consultation and drain construction, the Shire has time to monitor the 'without the drain' scenario of a CSD Scheme and compare the results five years after the drain was constructed. The result of the cost-benefit analysis would then show if the Shires' investment paid off.

Although default values as set out in the Model were used in calculating the salinity benefits and downstream costs, it would not be advisable to monitor these variables to come up with actual figures. The sensitivity tests undertaken showed that the economics of the CSD Program is still attractive without salinity benefits. Similarly, the downstream cost of the Program is negligible (0.06 per cent of the total cost) and the impact of increasing the cost even by ten times would have minimal impact on the economics of the Program.

5. CONCLUSIONS AND RECOMMENDATIONS

The CSD Program has a benefit-cost ratio of 3.1 :1 which shows that the Program is achieving its goal of providing cost-effective drainage and ensuring that productivity of farms prone to salinity, waterlogging and flooding is maintained, if not improved. The results of the evaluation also showed that the responsibilities in managing salinity and waterlogging problems were shared between the government and the community.

The agriculture benefits of community surface drains were achieved mainly through the farmers' initiative to invest in farm works to improve farm productivity and at the same time prevent and/or minimise the effect of salinity, flooding and waterlogging.

The results of the evaluation also indicated that there are large regional development benefits from surface drainage schemes not included in the economics of the salinity management plans (SMPs). The medium to long-term estimates of changes in catchment enterprise composition, gross margin and surplus net of operating costs, and depreciation also showed that the benefits of the program will be further underestimated.

Regional averages and default values in the DEM were used in the analysis which highlights the lack of primary data. Furthermore, data for the pre-drain situation were collected only after the drains were constructed. These shortcomings were corrected by undertaking sensitivity tests of some variables.

Recommendations for further research;

1. The calculation of the benefits to the road system can be improved if the local government is able to establish a system to identify the repairs and maintenance costs 'before' and 'after' drain construction. This will provide them with information on whether the benefits from drains outweigh the investment, and

2. The impact of increased productivity on regional development should also be investigated. The results of this evaluation justify the acceleration of the surface drainage (arterial drainage network) component in the regional development initiative.

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7. ATTACHMENT

7.1 Attachment 1 - Data Sets and Assumptions Used in the Evaluation of the CSD Program

Agriculture Production with the Project

Enterprise	% of the area	Gross Margin ($/eff. ha)	water use (ML/ha)
Dairy farms	65%	$1,491	4.41
Mixed farms	35%	$263	2.22
Horticulture	5%	$3,834	5

Agriculture Production without the Project

Enterprise	% of the area	Gross Margin ($/eff. ha)	water use (ML/ha)
Dairy farms	65%	$1,275	4.41
Mixed farms	35%	$254	2.22
Horticulture	5%	$3,834	6

Sources: F. Johnson (area)
MDBC Draiange Technical Report No. 2 (water use in dairy and mixed farms)
O. Montecillo (gm, water use in horticulture)

Salinity loss function

MDBC Salinity Function

Age	%
0	0.00%
10	13.00%
20	18.00%
30	20.00%
40	22.00%
50	23.00%
60	23.00%
70	23.00%
80	23.00%
90	24.00%

Shallow Watertables

Year	Area (ha)
-40	0
-30	0
-20	0
-10	383
1	5,743
10	7,275
20	8,424
30	9,189
40	10,721
50	11,487

Sources: Drainage Evaluation User Manual Table 4.1 (Water Use Intensity, 4 ML/ha)
% from data used in MDBC Drainage Technical Report No. 2

Waterlogging and Flooding

Waterlogging	Dairy	Mixed farming	Horticulture
Yield losses due to waterlogging [1]	6.25%	25%	0%
Proportion of the total area of each crop type affected by waterlogging [2]	53%	53%	53%

Flooding	Dairy	Mixed farming	Horticulture
Yield losses due to flooding [1]	12.5%	12.5%	100%
Proportion of the total area of each crop type affected by flooding [2]	5%	5%	5%

Sources: [1] Sheridan Maher, Pasture Specialist, DNRE Tatura
[2] DEM User Manual

Yield losses based on results of three year-field based research

Duration (no. of days)	Yield loss	% of year	Effective loss	Comments
<7	0	1	0	based on field data
7-14	0.10	0.16	0.0160	"
15-28	0.15	0.16	0.0240	"
29-63	0.25	0.25	0.0625	"
64-84	0.25	0.50	0.1250	reasonable estimation based on above
>84	0.50	0.50	0.2500	"

Source: Sheridan Maher, Pasture Specialist, DNRE Tatura

Notes:

- If seasonality of flooding occurrence is wrong then the above yield losses will need to be changed.
- Stocking effects (pugging damage) are not included.
- flooding occurred during winter/spring
- pasture fully inundated for most of time

Surface drainage and landforming

Year	Surface drainage without project (%)	Surface drainage with project (%)
1	0%	5.84%
2	0%	25.33%
3	0%	44.75%
4	0%	63.09%
8	0%	100.00%
50	0%	100.00%

Year	Landforming without project (%)	Landforming with project (%)
1	5.00%	5.00%
5	10.00%	40.00%
10	20.00%	70.00%
30	40.00%	70.00%
40	40.00%	70.00%
50	40.00%	70.00%

Source: F. Johnson, CSD Program Coordinator DNRE Tatura

Drainage effectiveness

	Effectiveness in reducing losses (%)		
	Salinity	Water-logging	Flooding
Sub-surface drainage only	90%	0%	10%
Surface drainage only	10%	10%	50%
Landforming only	15%	40%	10%
Sub-surface & surface drainage	90%	10%	50%
Sub-surface drainage & landforming	90%	40%	10%
Surface drainage & landforming	30%	60%	70%
Sub-surface drainage, surface drainage & landforming	90%	60%	70%

Source: MDBC Drainage Program Technical Report No. 2 and DEM User Manual

	$
Landforming cost ($ per ha)	$1,200
Drain operating and maintenance cost	$350 per km

Sources: F. Johnson, CSD Program Coordinator DNRE Tatura

Reuse

It was assumed that 6% of the surface water was reused at an economic value of $30 per ML.

Downstream impacts (Source: DEM User Manual)

Method 1. DEM Method - Calculates Salt Loads

Groundwater Salinity (uS/cm) - 3,390.49

Surface Drainage Parameters

Areas with Surface and Sub-surface Drainage

PD_1.5 (%)	50%
DD_1.5 (m)	2.00
LD_1.5(km / sq km)	0.02

Areas with Surface Drainage Only

PD_1.1 (%)	10%
DD_1.1 (m)	2.00
LD_1.1 (km/sq km)	0.02

Sub-surface Drainage Parameters

Rate of Groundwater Extraction - 1 ML/day

The Salinity cost at Morgan was valued as per the DEM User Manual

Farmers' Other Capital Investments (Drained Area)

Farm drain	$55 per ha	25% of total area
Pasture establishment	$445 per ha	10% of dairy area
Herd increase	$600 per cow	1 for every 10 ha of dairy farm

Source: Case study of the Ferguson Road and Lukies Road CSD Schemes