ECONOMICS OF IRRIGATION

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ABSTRACT

The economics of irrigation to both the nation and the farmer are outlined. A hypothetical farm is used which is being developed within a community irrigation scheme for livestock production and the development over a number of years is followed. A similar exercise is carried out for a farm using a ground water source where major emphasis is on mixed farming (cropping and livestock). Development on this farm is carried out without any assistance in the form of irrigation suspensory loans as compared to the farm within a community scheme which receives such assistance. Implications of the economic study are discussed, which lead to the conclusion that an increased rate of irrigation development could be achieved nationally if the present community irrigation scheme policy was extended to private irrigation development. Such development would be very profitable from the national viewpoint and hence the individual farmer's viewpoint.

INTRODUCTION

The economics of any farming venture is always a subject of much debate. This is because it relies very much on the assumptions used in relation to costs and expected increases in income. Irrigation is no exception to the rule. In fact it tends to attract more than its fair share of comment. The major areas of debate are the cost of construction; expected increases in crop yields and stock carried as a result of irrigation; the rate of development; and the relative effect of inflation on costs and benefits over time.

In the majority of situations the discussion tends to centre around the assumptions on climate and soil type as they affect crop yields and stocking rates; assumptions on the individual farmer's managerial skill and aspirations as they affect crop yields, stocking rates, stock performance and rate of development; assumptions on the method and cost of irrigation in relation to water source, land contour and farmer's personal views.

Thus, there are many factors which can affect the profitability of irrigation. However, in order to answer the question of economics of irrigation, I propose to look at the development of two types of irrigation -

(i) Private spray irrigation from a ground water source for crop and stock.

(ii)Border dyke irrigation from a community scheme for stock.

The basis of my observations will be from my experiences throughout Canterbury in areas with a good Lismore soil with an average rainfall of 650-750 mm per year. The farmer I have used in the examples has a medium debt load, wants to operate an efficient irrigation farm and seeks out modern farm management and puts it into practise successfully. (McFadden, 1978; Ritchie, 1978). Due to limitations of space, full details of assumptions and budgets cannot be included in this paper but they are available from the author.

NATIONAL VIEWPOINT

(a) Case Study Farm

In order to derive a base for our assessment of the economics of irrigation, I have taken a sample 200 hectare farm (Table 1) and using present price expectations for the 1979-80 year have developed a budget. Our case study farmer is expecting a reasonable income for the 1979-80 year but after paying taxation has little income available for above normal personal spending. However, because of taxation incentives there is a small amount of capital for on-farm re-investment.

TABLE 1: Physical Details – 200 hectare farm – dryland.

		Hectares
Spring Cover:	Pasture	100
	Lucerne (grazing)	50
	Lucerne (hay)	20
	Wheat	10
	Barley	10
	Greenfeed	10
Stock:	Ewes	2,000
	Rams & Others	30
Stock Performance:	Lambing %	95
	Wool/ewe	4.5 kg
Crop Yields:	Wheat	2.7 tonnes/ha
	Barley	2.2 tonnes/ha

(b) Cost – Benefits of Spray Irrigation from Gound Water.

Usually a farmer moving into this method of irrigation is only able to irrigate a little over 100 hectares from one bore (flow rate 2800 litres/minute) In the following example I have assumed the irrigation system installed will be able to irrigate 110 hectares on a 28 day return interval and would cost a total of $76,250 or $693.18 per hectare.

TABLE 2: Budget – 200 hectare farm – dryland.

	$
Income:	
Lambs	27,550
Cull ewes	6,400
Wool	18,900
Wheat	3,710
Barley	2,420
Total Farm Income	58,480
Expenditure:	
Purchase of stock	14,200
Stock expenses	4,000
Crop expenses	2,330
Pasture &/or lucerne establishment	2,000
Pasture &/or lucerne maintenance	3,400
Winter feed establishment	800
Sundry vehicle expenses	2,000
Repairs & maintenance (buildings, fences etc)	1,000
Rates	700
Insurance	500
Hay	2,000
Wages (casual)	1,000
Mortgage (interest)	8,000
Total Farm Expenditure	41,930
Cash Farm Surplus	17,050
Minus – principal repayments	3,000
– taxation	4,371
Cash Surplus	9,679
Available for personal living.	

The farming systems evolved using spray irrigation from bores are many and varied (Englebrecht, 1978) depending on the farmer's personal aspirations. In this example I have assumed the farmer wishes to maintain his present stock numbers but convert from buying replacements to breeding his own replacements and increase the area and yield of crops grown. (Tables 3, 4 and 5).

TABLE 3: Cover summary (Spring) – developing spray irrigation farm.

Year	0	1	2	3	4
Dryland –					
Pasture	100	40	40	40	40
Lucerne (grazing)	50	40	40	40	40
Lucerne (hay)	20	–	–	–	–
Wheat	10	110	10	10	10
Barley	10	–	–	–	–
Greenfeed	10	–	–	–	–
Irrigated –					
Pasture	–	30	30	30	30
Lucerne (grazing)	–	10	20	20	20
Lucerne (hay)	–	10	–	–	–
Wheat	–	20	20	10	10
Barley	–	20	10	10	10
Peas (field)	–	10	10	10	10
Peas (garden)	–	–	10	10	10
Grass seed	–	–	–	10	10
White seed	–	10	10	10	10
Total Area	200	200	200	200	200

TABLE 4: Stock summa y – developing spray irrigation farm

Year	0	1	2	3	4
Ewes	2000	1750	1750	1810	1810
Ewes Hoggets	–	–	300	440	440
Rams & Other	30	30	30	30	30
Fattening Hoggets	–	100	200	300	300

TABLE 5: Crop yields (irrigated) – developing spray irrigation farm.

	tonnes/hectare
Wheat	4.0
Barley	4.5
Peas (field)	3.0
Peas (garden)	4.0
Grass seed	0.8
White Clover	0.3

If we now compare the additional costs and benefits over time, we find an internal rate of return (I.R.R.) to the nation of 16.4% or net present value at the 10% discount rate of $73,588 or $669 per hectare irrigated, using current prices. This is a very profitable investment from the nation's point of view when we consider the present Treasury guideline that such projects must have an I.R.R. greater than 10%.

(c) Cost Benefits of Border Dyke Irrigation from a Community Scheme.

In the example that follows I have taken our base dryland farm and assumed it is in a large community irrigation scheme which is about to be developed. The costs of development are outlined in Table 6 for the case study farm. The actual details of development are given in Tables 7 and 8.

This is a similar rate of development and development programme as outlined by Ritchie (1978), the important feature being the use of crops in the development programme and the change in stock policy from one of buying replacements to breeding replacements. This investment shows an internal rate of return of 11.82% or net present value at the 10% discount rate of $30,546 ($278/ha irrigated) again indicating the profitability of irrigation development.

(d) Comments from the National Viewpoint

The preceeding analysis gives an overall view of the economics of irrigation development from national viewpoint. There are several benefits and costs which have been omitted from the analysis.

(i) Additional Labour – For the development of both schemes, labour for construction has been included at contract rates which would cover all labour required for developmment. However, additional labour for the status quo situation following development has only been allowed for at minimal rate (an additional $1,000 per year in sample farms). This is probably adequate for the farming systems envisaged here and the farm size discussed. However, larger farms exist which, if fully developed, may require an additional labour unit in the form of a married man, with all the associated costs of housing and vehicles.

TABLE 6: Cost of border-dyke irrigation-development within a community scheme. = $864 per hectare developed

	Total	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
River Headwork	17,000	5000	5000	5000	2000						
Off farm reticulation @ $280/ha	56,000		14000	14000	14000	14000					
On Farm –											
1. Earth-works											
Headrace 8000 m @ $10/m	8,000										
Supply race 1640 m @ $0.30/m	492										
Border dyking 190 ha @ $250/ha	47,500										
	55,992					2946	14,735	14,735	11,788	11,788	
2. Structures											
Dam 187 @ $65	12,155										
Sills 640 @ $11	7,040										
Weirs 8 @ $40	320										
Gates 75 @ $20	1,500										
	21,375						4,424	4,424	4,424	4,424	3,679
3. Sensor Units											
16 @ $50	800										
Cable down middle	2,200										
	3,000						600	600	600	600	600
4. Fencing (part electric)											
18,000 @ 0.60c	10,800										
Total Cost	$164,167	5,000	19,000	19,000	16,000	16,946	22,039	22,039	19,092	19,092	5,959

TABLE 7: Cover summary (Spring)* – developing border-dyke irrigation farm.

Year	4	5	6	7	8	9	10	11
Dryland –								
Pasture	100	80	70	40	10	–	–	–
Lucerne (grazing)	50	40	40	20	10	10	10	10
Lucerne (hay)	20	20	–	–	–	–	–	–
Wheat	10	20	20	20	20	–	–	–
Barley	10	–	–	–	–	–	–	–
Greenfeed	10	20	10	10	10	–	–	–
Irrigated –								
Pasture	–	–	30	60	100	140	170	170
Lucerne (grazing)	–	–	–	20	20	20	20	20
Lucerne (hay)	–	–	20	–	–	–	–	–
Barley	–	10	10	–	–	–	–	–
Peas	–	10	20	30	30	30	–	–
TOTAL	200	200	200	200	200	200	200	200

TABLE 8: Stock summary* – developing border-dyke irrigation farm.

Year	4	5	6	7	8	9	10	11	12	...
Ewes	2010	1760	1800	1900	2050	2500	3080	3150	3200	...
Ewe Hoggets	–	–	300	500	700	800	900	1000	1000	...
Rams & Others	30	25	25	30	40	40	45	45	50	...
TOTAL E.E.	2031	1777	2077	2271	2568	3088	3741	3881	3935	

* Years 0-3 no on-farm development occurs.

(ii) Additional Machinery - In the preceeding analysis, contract rates have been allowed for all harvesting machinery. While these will be adequate to cover this cost, the question must be asked 'Is the machinery available in the area under consideration?'.

(iii) Stock Water Schemes – Often the cost of keeping an existing stock water race system in operation after the construction of a major irrigation scheme is prohibitive and therefore a

piped system is very necessary.

(iv) Saved Drought Costs – In the preceeding analysis an 'average' year has been assumed. However, considerable variation can occur about the mean. For pasture production this variation under dryland conditions is plus or minus 48% and 12% under irrigation at Winchmore. (Rickard, 1964). The dryland farmer generally farms for an average year, takes an advantage of the above average year by making additional hay which he uses in the below average year. However, the feed made in the above average years do not always cancel out the below average year. Therefore, in two or three years out of ten there is an additional cost of $2 to $3 per ewe equivalent carried on the dryland farm. In the irrigated situation no such cost occurs. Therefore, this is a benefit to our irrigation farmer.

(v) Secondary Benefits and Costs – Irrigation development on a large scale can have marked effects on regional development. Brown (1978) states that irrigation affects the level of economic activity in the local region through four routes – (a) The expenditure made during scheme construction. (b) The expenditure on scheme operation and maintenance. (c) The additional income and output from irrigated farms. (d) The additional input purchases made by irrigation farmers. The impact of each of these expenditure flows is felt by regional businesses and the local population. Galwey (1977) concluded that the Kakanui-Waiareka Downs irrigation scheme could help stabilise employment levels in North Otago and have a significant impact on regional income levels. These secondary benefits raised the expected internal rate of return of this scheme from 10.5% on the project itself to 20.5%.

(e) Importance of Price and Yield Assumption

In this analysis no attempt has been made to quantify the importance of product price, stock performance, crop yields, cost data or speed of development assumptions. However, these points much be considered if any implications are to be drawn from the preceeding analysis. The irrigation subsidy policy and the livestock incentive scheme, linked with a strong on-farm advisory service, tend to be having a very positive effect on the rate of development and stock carrying capacities. The Lower Waitaki and Glenavy-Morven Irrigation schemes at this stage appear to be out-performing the original prediction as in the pre-scheme economic reports. (G. H. McFadden (pers. com.) and J. R. Oliver (pers. com.).

From the national and indivdiual farmer viewpoint, one of the most critical price assumptions is that for electricity. In the preceeding analysis, a current price of 3.2c per unit has been used. However, with the current talk of surplus of hydro-electricity capacity, one wonders whether from the national viewpoint we should use the marginal cost of electricity. This has been spoken of as low as 1.0c per unit. This would have the effect of reducing the example farm electricity account from $5,676 per year to $1,774.

A similar argument also holds for the actual cost of spray irrigation equipment. The majority of equipment for spray irrigation is constructed in New Zealand. However, some of the equipment could be imported at a smaller cost then the manufactured product because of mass production overseas. Should this additional cost of using the New Zealand product be a cost against irrigation or against employment of New Zealand labour?

INDIVIDUAL FARMER'S VIEWPOINT

The individual farmer's point of view differs in certain respects from the national viewpoint in that certain incentives are available to assist the farmer in development.

Irrigation development is very profitable for the farmer in both situations explored here. In the case of development from a ground source of water the cash flow has a net present value of $55,780 ($507 per hectare irrigated) at the ten percent discount rate. However, it is the farmer in a major community scheme who really benefits with a net present value of cash surpluses of $135,204 (or $711 per hectare irrigated) at the ten percent discount rate. This cash surplus is after subtracting all costs including mortgage repayments and taxation from the gross income. In other words, it is the additional finance the farmer has available to meet personal living.

However, it is perhaps not the magnitude of these two figures which is important but the additional cash surpluses per year during the development programme which go to make up these two figures. In the case of spray irrigation from a bore the first three years see a loss situation followed by large increases in additional cash surplus ($10,000 – $15,000 per year for years 4 to 6). However, the real problem occurs from the individual farmer's viewpoint in years 7 to 15 where the additional cash surplus deteriorated from $4000 to $1800 per year as the effects of additional taxation and principal payments became apparent. Year 16 sees the mortgage paid off and therefore the additional cash surplus increases to $9,400 per year. On the other hand, the additional cash surplus available to the farmer does not diminish to such a minimal amount when the farmer is in a community irrigation scheme because of a smaller mortgage with a longer term.

The reason for the difference in cash surpluses between the two systems of irrigation include the following –

(i) Area Irrigated In the case of the river source of water 95 percent of the farm has been irrigated, whereas with the ground water source only 55 percent of the farm has been irrigated.

(ii) Community or Private Development The farmer with the ground water source (private development) must service, in loan form, the complete cost of the loan ($76,250 or $693 per hectare) on a 15 year term plus the cost of electricity, whereas the farmer in a community irrigation scheme must only service half of the on-farm capital cost ($40,183 or $211 per hectare irrigated) on a 25 year mortgage, half of the off-farm water reticulation cost ($28,000) on a 40 year mortgage and none of the headworks cost (Table 9).

(iii) The Time Required for Development Perhaps the time elapsed between the spending of the first dollar on any development programme and

TABLE 9: Annual Cost to Own and Operate* an Irrigation Scheme.

	Community (190ha)		Private (110 ha)	
	Total	per ha Irrigated	Total	per ha Irrigated
	$	$/ha	$	$/ha
Cost of Capital	5580	29.37	9463	86.03
Water Charge	3352	17.64	–	–
Electricity	–	–	5676	51.60
	8932	47.01	15139	137.63

*excludes repairs and maintenance.

spending the last dollar has the greatest influence on the profitability of the scheme. This is especially true when we use the relatively high discount rate of ten percent. With the large community scheme involving border-dyke development it is not until perhaps Year 4 that first water is available to the first farm and until perhaps Year 16 or 17 is the scheme fully developed. From the individual farmer's point of view it takes a number of years (5 to 8) for development to be completed and still more for stock numbers to reach their optimum. However, this time is not all lost from the farmer's point of view as it gives him time to adopt the new management systems so necessary for irrigation farming. The development of spray irrigation on a property can be almost instant (one year), the major problem being in many circumstances that the farmer has insufficient time to become familiar with the new farming system he must evolve.

Time does not allow analysis of other farming systems or other irrigation systems. However, I do believe sheep farming is just as profitable as the crop-sheep farming system under spray irrigation as outlined here. (Englebrecht, 1978), the key to success being the individual farmer's personal preference coupled with the suitability of the soil type he is working with.

When stock farming is envisaged using a spray irrigation system from a bore, border-dyke irrigation should also be considered. Interesting developments have been occuring on Mr L. R. Kingsbury's property (P.I. Lord, pers. com.) at Dorie where he has constructed a pond (1 hectare) for conversion of a small flow of water from a bore (4500 litre/min.) to a large flow (18000 litres/min) more suitable for border dyke irrigation. This system has the advantage over spray irrigation of having a lower annual operating cost (similar capital cost, but half electricity costs as there are no spray lines), is less labour intensive, and is more suitable for stock (no problem with fencing.).

FUTURE DEVELOPMENT OF IRRIGATION IN NEW ZEALAND

The question you may be asking yourself at present is 'If irrigation is so profitable, why don't more farmers want it?' The answer for community irrigation schemes is that generally farmers do want irrigation when they are in areas where it is profitable from the national viewpoint. However, the answer to the question for private development of irrigation schemes, where less than four farmers are involved, is more complex. In this situation no suspensory loans are available. Farmers in this situation have become reluctant starters in irrigation because of a number of complex reasons.

Many farmers find themselves in a relatively comfortable position at present where they are able to achieve many of their immediate goals and therefore wonder what they will do with a relatively small additional cash surplus as a result of development. Coupled with this relative comfort, they are uncertain of the economic future of their properties and are concerned with the instability in the work force outside the farm gate which affects then so dramatically (e.g. transport industry and meat processing industry). As a result of this uncertainty of the future and the relative comfort some farmers enjoy at present, many prefer to minimise fixed costs rather than maximise net profit. Or, in other words, they believe that by keeping their overheads to a minimum, if their beliefs on the uncertainly question eventuate, they will be better able to withstand the problems than their counterparts with large mortgages and high numbers of livestock For instance, in the example farm, the farmer would have to mortgage his property for $76,000 plus meet an average annual electricity charge of $5776. Many farmers are not prepared to do this, despite the investment being in the best interest of the nation.

Government policy has gone some way to meeting the economic uncertainty question many farmers are concerned about with the following policies.

– a floating exchange rate
– supplementary minimum price scheme
– Livestock Incentive Scheme
– Land Development Encouragment Loan

The last two are particularly relevant to development. both involve suspensory loans. From the farmer's point this is important in itself, but equally important, it involves the nation in a direct investment. This means to the farmer 'I am not alone in this investment – the whole nation is with me'.

The question I wonder on is – 'private development of irrigation is very profitable from the national view point – how can we encourage more farmers to carry out this form of development?' My answer to that question is supensory loans similar to the Livestock Incentive Scheme or the Land Development Encouragement Loan.

To test this hypothesis I recently asked Farm Advisory Officers throughout the country what private irrigation development they would expect over the next three years in their areas under two assumptions –

(A) Present method of financing.

(B) Half of finance for development was in the form of a suspensory loan and the remainder on a normal R.B.F.C. mortgage.

Under Assumption A we expected 15,500 hectares to be developed over the next three years, whereas Assumption B could possibly see 64,000 hectares developed. (Table 10). This is all additional* to present subsidised community scheme development. My estimate on the profitability of this development is that we expect an internal rate of return of about

TABLE 10: Irrigation development over next three years.

By Areas	Assumption A	Assumption B
North Island	6 000	24 000
Nelson-Marlborough	1 000	2 500
Canterbury	7 000	30 000
Otago-Southland	1 500	8 000
TOTAL:	15 500	64 000
By Land Use		
Intensive Cropping & Horticulture	5 000	13 000
Dairy	1 000	6 000
Cropping & Intensive Sheep	6 500	36 000
Intensive Sheep	3 000	9 000
TOTAL:	15 500	64 000

fourteen percent.

I believe this internal rate of return for this development is conservative for a number of reasons–

(a) The private or small community scheme relies very much upon the initiative, flexibility and enthusiasm of the individual farmer. Those farmers who have these necessary qualities of an irrigation farmer quickly develop their property for efficient irrigation, while those without the initiative etc. remain dry-land and hence do not influence the overall profitability of the irrigation scheme.

(b) Single farm irrigation development is very quick to reach full development because only the best farmers are involved and off-farm work is minimal.

(c) Single farm irrigation development brings no pressure to bear on farmers who do not wish to irrigate and therefore these farmers have no effect on the overall scheme economics.

It is not envisaged all this development will use water from a ground water source. In much of New Zealand, where irrigation is profitable there is a potential for immediate gains using surface water from streams and small creeks. This is particularly true in hill country regions where a small area of relatively flat land exists with potential for irrigation. This area may be used for intensive sheep and/or beef units and dairy farms. With correct management systems adopted, irrigation on these areas could see a dramatic increase in total farm production from each farm with a portion of its area irrigated. The additional irrigation as a result of the suspensory loan as outlined would result in a significant increase in national farm production.

Or in other words, we could see the following additional production per year within five years as a result of the initial three years change in policy. – 150,000 lambs - 36,000 head of mutton – 800,000 kg of wool – 40,000 tonne of crop 1,000,000kg of butterfat. As for the additional production as a result of horticulture and irrigation, I think there is little doubt of the economics. In the majority of cases you do not start a horticulture enterprise without irrigation.

* These figures are purely an estimate put up for discussion purposes only.

CONCLUSION

Irrigation development which is well planned from both an engineering and farm management point of view is profitable to the nation and the individual farmer. The present assistance policy for farmers in community irrigation schemes is resulting in a near optimum speed of development when we consider the resources available. However, despite the profitability of private irrigation development, there is considerable scope for an increased national rate of development of private irrigation schemes which would be very profitable to both the nation and the farmer. For this potential to be achieved, the farmer requires the assurance that the nation is with him.

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