THE ECONOMICS OF SPRAY IRRIGATION ON THE FAR NORTH COAST OF NEW SOUTH WALES

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1. SUMMARY

In the Far North Coast area, spray irrigation on a part farm basis is usually accompanied by a management system which also involves improved pastures and increased herd size. Of the twenty-five properties included in a survey it was found possible to give an estimate of annual net gains due to irrigation and pasture improvement in fifteen cases. Substantial net gains were observed on five farms, but there were apparent losses on six farms, and in four further instances the outcome appeared to indicate that irrigation had been a doubtful proposition.

Losses on some survey farms were probably due to failure to give attention to the following points:

(1) Technical aspects of irrigation, such as the frequency of irrigation and the quality of the pastures that it is used on.

(2) Need for expanded herd numbers if advantage is to be taken of a possible complementary relationship between feed use on the irrigated area and feed use over the whole farm.

(3) Use of irrigation on properties in the Tweed valley, where potential for its profitable use appears to be less than in the Richmond valley.

(4) Use of irrigation plants on areas of less than fifteen acres.

The results of the survey suggest that potential production gains from irrigation are greater than those estimated by Waring [1] in 1959. On five survey farms the production increase was estimated to be in excess of 200 lb. of butterfat per acre irrigated.

John Sands and Co.

Irrigation on the property of Mr. J. Whitney of South Gundarimba at the turn of this century.

[1] E. J. Waring, "Supplementary Irrigation of Pastures in Humid Areas," this *Review*, Vol. 27, No. 4 (December, 1959).

2. INTRODUCTION

In the Far North Coast area of New South Wales dairying is conducted under conditions of unreliable spring rainfall.[2] Even so, it is more profitable for farmers to aim for July-August calving than to defer calving until the period of flush summer growth.[3] Thus the area is one of marked production and income uncertainty for farmers, butter factories and the associated urban communities.

As early as the first decade of this century it was noted that portable spray irrigation plants could be one solution to this problem.[4] (See Appendix 3.) Almost fifty years later (1953) Rutherford reported of the Far North Coast area that:—

> "Irrigation is not practised to any extent throughout this area. Probably only 100 to 150 farmers are involved, comprising mostly vegetable growers and producers of tropical fruits on the Tweed. Some improved pasture under irrigation is practised by a group of dairy farmers in the Richmond Valley, particularly around Kyogle." [5]

Expansion since that date has been rapid and there are now approximately 500 licences let to farmers by the Water Conservation and Irrigation Commission. Of these some 300 are known to be for the irrigation of pastures. Thus, currently about eight per cent of the region's dairy farmers have irrigation licences. Important factors in the expansion since 1953 were improvements in the technical design of irrigation plants, including use of light-weight aluminium pipes and quick action pipe couplings, and the big yields achieved with newly established ladino white clover pastures.

The distribution of licences for pasture irrigation is shown in Map 1. In deriving the map, farmers using irrigation for bananas and vegetables were excluded. These farmers were identified as those having a small area irrigated and a pump size too small for the effective irrigation of pastures.

Invariably, in this region, irrigation is used to supplement natural rainfall on a limited area of improved or semi-improved pastures. These pastures are typically used, with "strip" or rationed grazing throughout the spring to add a high quality supplement to the feed available from non-irrigated pastures.

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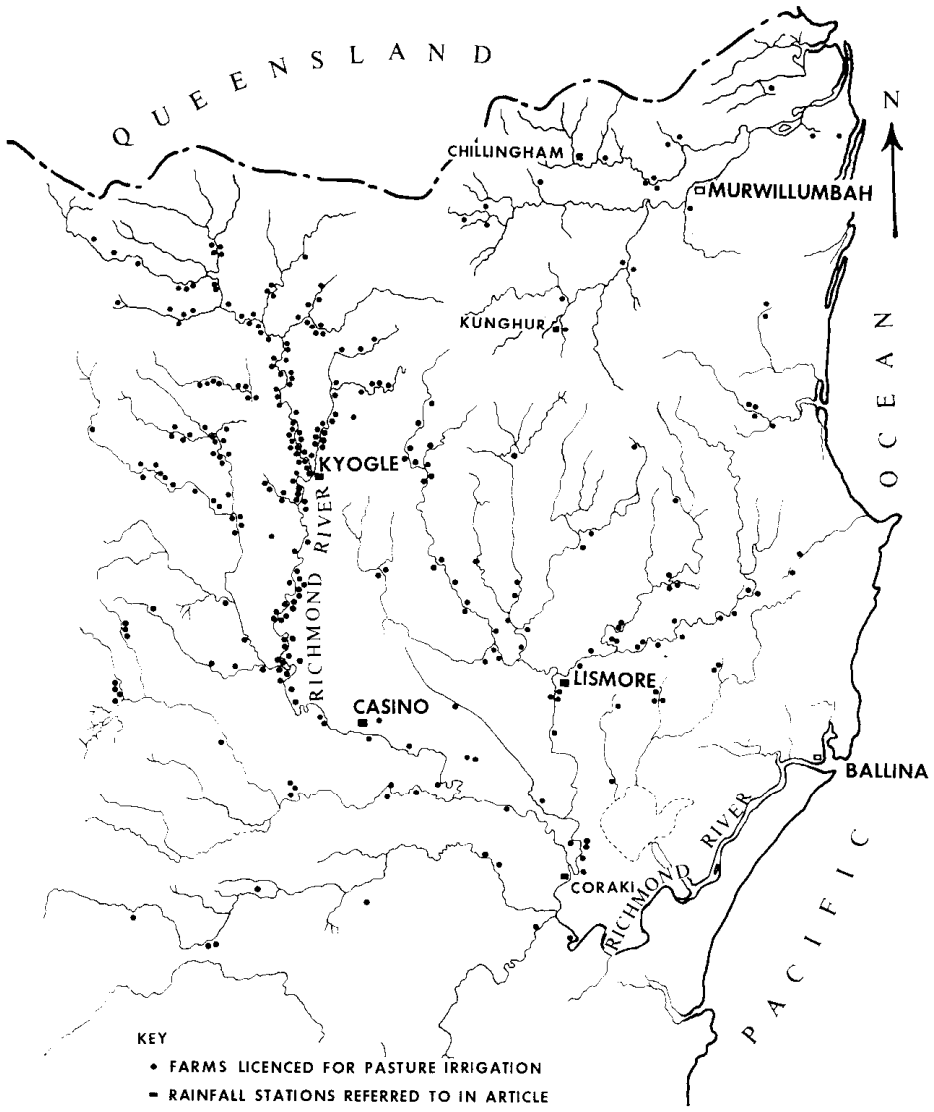
[2] See John Rutherford, "Rainfall Variability and supplementary Irrigation in Coastal New South Wales," this *Review,* Vol. 21, No. 1 (March, 1953).

[3] See I. W. Scott and G. B. Wilson, "Effect of Month of Calving on Production," *The Agricultural Gazette of New South Wales,* Vol. LXIII (July, 1952), p. 357, and W. T. Curtin, "Casino Dairyfarmers Lose £150,000 a Year." *Dairy Topics,* Vol. 9, No. 4 (July-August, 1963), p. 21.

[4] *Farm Life on the Richmond and Tweed Rivers* (Sydney: John Sands, 1906), p. 42.

[5] Rutherford, *op. cit.*



Map 1. Showing area surveyed

Farmers show a wide range of attitudes to the principles of using this type of supplementary irrigation. Some consider it to be merely a drought insurance and only use it when drought is well established. Others integrate it into their annual cycle of seasonal operations and irrigate in all but exceptionally wet years.

Views on the profitability of the practice have been equally diverse. Rutherford's attitude was one of virtually unqualified enthusiasm. But, in 1959, Waring [6] queried the enthusiasm that was currently in vogue among the advisers to the industry. His main suggestions were:—

(*a*) that preoccupation with production stabilizing aspects of irrigation could lead to excessively high costs and imperfect realization of production potential;

[6] Waring, *op. cit.*

(*b*) that possible gains were not as high per acre as was commonly believed;

(*c*) that cost per acre dropped substantially as area irrigated was increased; and

(*d*) that there was a tendency to neglect the opportunity costs of irrigation. It was considered that other means existed for achieving similar results and that these could in many instances be more profitable. In particular, he suggested that purchased or conserved fodder would be more economical for drought survival feeding.

These criticisms were timely. However, they were widely misunderstood and it was thought that they might be tending to discourage consideration of an investment which could still be the most profitable alternative open to some farmers. Accordingly, it was decided that there was need for a further study of the economics of sprinkler irrigation on a sample of North Coast dairy farms.

The specific objectives of the study reported here were to examine:

(*a*) the production gains achieved through using spray irrigation on the sample farms;

(*b*) the role of spray irrigation in the management programmes of North Coast farms;

(*c*) alternative methods for achieving the same effect on farm production and income;

(*d*) the adequacy of the irrigation design and the technical (engineering) efficiency of operation; and

(*e*) the costs, returns, and profitability of spray irrigation on the sample farms.

In Section 3 of the article, estimates are presented of the frequency with which irrigation plants need to be used in the region, if adequate moisture is to be provided for continuing active plant growth. Some details of the survey method and of the characteristics of the sample farms are presented in Section 4. Section 5 gives a brief discussion of the role of irrigation under North Coast conditions. An analysis of irrigation profits on the survey farms is presented in Section 6, while Section 7 is devoted to a brief discussion of the economics of existing alternatives to irrigation. Conclusions are presented in Section 8, and further related aspects are presented in three appendices.

3. IRRIGATION REQUIREMENTS FOR CONTINUOUS PLANT GROWTH

In a previous article, Mason[7] discussed the relationship between seasonal butterfat production and an annual index of soil moisture for three farms in the Far North Coast area. The soil moisture estimates were calculated by the Thornthwaite method.

[7] George Mason, "Towards a Production Function for Supplementary Irrigation on Far North Coast Dairy Farms", this *Review*, Vol. 31, No. 2 (June, 1963).

Subsequently, the Thornthwaite method, using daily temperature and rainfall records, has been incorporated in a computer programme to estimate the number of irrigations required per annum for an eleven year period in six Far North Coast locations. It was assumed that each irrigation was of 1½ inches and took place when soil moisture dropped to 3.5 inches in the top foot of soil, or to a deficiency of 1.5 inches below field capacity for these alluvial soils. For two locations the period was from July 1951 to June 1962, while for the remaining four, the first and last dates were a year later. Some results of this analysis are summarized in Table 1, which also gives the average number of irrigations required per year and the equivalent quantities applied. The locations are shown on Map 1.

TABLE 1

Number of Irrigations Required at Six Locations: 1951-52 to 1962-63

Period	Chilling-ham	Kunghur	Kyogle	Lismore	Coraki	Casino
	No.	No.	No.	No.	No.	No.
1951-52	10	11	n.a.	n.a.	n.a.	n.a.
1952-53	6	8	10	6	9	12
1953-54	7	7	8	9	11	11
1954-55	4	4	5	5	6	6
1955-56	6	6	6	6	7	7
1956-57	9	8	9	8	9	10
1957-58	8	9	10	10	10	10
1958-59	4	3	5	5	4	8
1959-60	6	6	6	6	3	10
1960-61	5	5	7	7	8	6
1961-62	4	3	4	4	6	3
1962-63	n.a.	n.a.	6	5	6	9
Average No. per Year*	5·9	5·9	7·0	6·6	7·3	8·3
Average Water Requirements per Year* ..	8·9″	8·9″	10·5″	9·9″	10·9″	12·5″

* For the comparable period 1952-53 to 1961-62.

The economic analysis reported here is based on productivity in the five years 1957-58 to 1961-62. Number of irrigations required per year over this period was less, on average, than the average requirement for the whole period. Also, inspection of rainfall records over 45 years to 1961-62 indicates that the irrigation requirement in the survey period would be approximately the same as the long term average requirement. Figure 1 shows the average irrigation requirement per month over the ten year period for which comparable data is available for the six locations. The source of the data is the results of the irrigation frequency calculations, but expressed in this figure in points of water applied by irrigation (one application = 150 points of irrigation water).

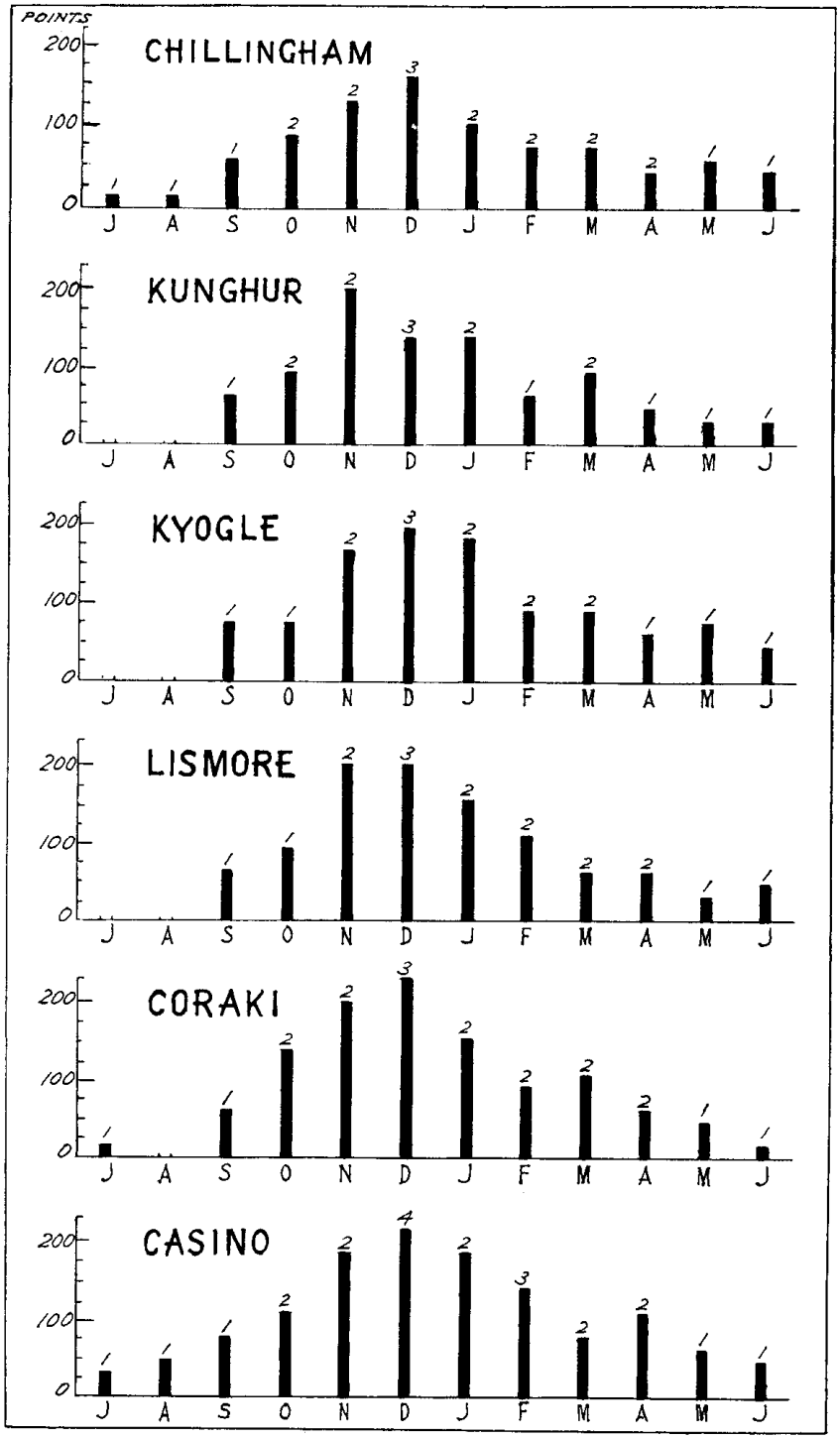


Fig. 1. Average points of irrigation water per month 1952-53 to 1961-62. (Units superimposed on each column are the maximum number of irrigations required in any one month over this period.)

4. THE SURVEY

Survey Method

A list of the names and addresses of farmers holding irrigation licences was obtained. The farms were then plotted on a locality map (Map 1) and a total of twenty-five farms were selected at random from the groups falling within each of seven subdivisions of the Richmond and Tweed watersheds. The number included in each subdivision was proportional to the total number of licences held within the area. Farmers were then contacted by 'phone and an interview arranged. They were replaced in the sample if it was found that they did not wish to co-operate or that it was not three years since they bought their irrigation plant.

It was found difficult to obtain the necessary co-operators in this way and some replacements were obtained on the recommendation of the District Agronomist. The farms surveyed were therefore not a random sample of the farmers holding irrigation licences in the area. However, this procedure did ensure that properties were visited throughout the area, and that at least some farmers who did not use their irrigation plants intensively were included.

Of these 25 properties 8 have been discarded in the detailed analysis because of the absence of satisfactory records. However, these farms are included in some tables and this will be indicated by reference to the "full sample" and "restricted sample" groups.

For each of the 17 remaining properties a comparable unimproved property was visited to obtain brief details of farm organization and production levels. Again it was not possible to get satisfactory details for all of these properties and the total number included in the comparative tables is 16. However, the grouping of both irrigated and non-irrigated properties into separate Richmond and Tweed river groups at each stage of the analysis ensures that limited interpretation of the comparisons can be made.

In the analysis of the profitability of irrigation, which is presented in Section 6 of the article, two of the 17 farms with satisfactory records had also to be excluded because the farm programmes used were too complicated for analysis.

Characteristics of the Sample Farms

Table 2 shows details of the effective farm area and area of creek flats. Effective farm area excludes uncleared areas, unused swamps and areas used for purposes other than dairying. It will be noted that the irrigated properties in the Richmond Valley have greater areas of creek flats than the non-irrigated properties, and are slightly larger in effective farm area.

For the irrigated groups, Table 3 gives further details of the extent of irrigation on the sample farms in the dry 1960-61 season. It was not possible to obtain an accurate measure of the amount of water applied. This table also shows details of the areas stated on irrigation licences issued in the Richmond-Tweed area to farmers known to be undertaking pasture irrigation. It will be noted that the largest number of irrigators have licences for 7-10 acres. However, of the 23 survey farmers who used

TABLE 2

Some Characteristics of the Survey Properties

River Valley	Classification	Number of Properties	Average Effective Farm Area *	Average Area of Creek or River Flats
		No.	Acres	Acres
Richmond	Irrigated	13	229	120
	Non-Irrigated ..	11	214	65
Tweed	Irrigated	4	171	67
	Non-irrigated ..	4	205	79

* Farm area excluding uncleared area, permanent swamps and area not used for dairying.

TABLE 3

Frequency Distribution of (1) *Area Irrigated on Sample Properties in* 1960-61 and (2) *Areas Licensed for Pasture Irrigation in the Richmond Tweed Region.*

Area Irrigated in Acres(1)	Number of Farms					Acreages Licensed for Pasture Irrigation(2)
	Richmond		Tweed		Total	Richmond and Tweed
	Full Sample	Restricted	Full Sample	Restricted	Full Sample	Number of Farms in Size Group
Nil	....	....	2	2	2	....
6 or less	....	....	....	....	....	20
7-10	1	....	1	0	2	118
11-15	5	2	1	1	6	45
16-20	1	....	....	....	1	49
21-30	5	4	1	1	6	41
31-50	6	5	....	....	6	16
More than 50.. ..	2	2	....	....	2	5
	acres	acres	acres	acres	acres	acres
Average Area Irrigated	29·5	31·0	9·1	9·0	25·9	n.a.
	No.	No.	No.	No.	No.	No.
Total Number of Farms	20	13	5	4	25	294

TABLE 4

Herd Size and Per Farm and Per Acre Production in 1961-62 *on Sample Properties*

Area and Group	Number of Farms	Herd Size	Farm Production	Per Acre Production
	No.	No. of Cows	lb. Butterfat	lb. Butterfat
Richmond—				
Irrigated	13	86	17,760	78
Non-irrigated	11	58	11,970	56
Tweed—				
Irrigated	4	55	8,780	51
Non-irrigated	5	67	10,660	52

irrigation in 1960-61, only two irrigated an area as small as 10 acres. It was observed that a number of survey co-operators had found an irrigated area of 10 acres to be too small and had substantially increased the area.

Productivity of Irrigated and Non-irrigated Properties

Details of herd size and per farm and per acre production are shown in Table 4 for the 1961-62 season. Herd size is the total number of cows milked during the year. Per acre production is based on the effective farm area. It is significant that per acre production shows little difference between the irrigated and non-irrigated groups in the Tweed area, but shows a substantial difference —40 per cent—in the Richmond area.

In view of the small number of farms involved, this fact is certainly not to be taken as specifically indicating that irrigation is less profitable in the Tweed Valley. But it is consistent with this conclusion. Further details of per acre production are presented in Table 5. There is little indication, that the relative position of irrigated and non-irrigated groups has changed in the Tweed. But in the Richmond the irrigated group show a distinct improvement in productivity.

TABLE 5

Production Per Acre on Sample Properties: 1958-59 to 1961-62

Area and Group	No. of Farms	1961-62	1960-61	1959-60	1958-59
		lb. butterfat	lb. butterfat	lb. butterfat	lb. butterfat
Richmond—					
Irrigated	13	78	65	68	62
Non-irrigated ..	11	56	38	51	45
Tweed—					
Irrigated	4	51	49	54	48*
Non-irrigated ..	5	52	51	53	48†

* Three farms.

† Four farms.

5. THE ROLE OF IRRIGATION

The use of part of a farm for irrigated improved pastures could affect whole farm production in one of three ways. One possibility is that the utilization of other grazing material available could be unchanged. Thus, there could be a supplementary effect with the gain in production being directly proportional to the added production of herbage. Another possibility could be a competitive effect with grazing of the added herbage substituting for grazing of existing pastures. Finally, it is feasible, especially if irrigation is accompanied by higher stocking rates, for the effect to be complementary[8] through improved year-round utilization of pastures over the whole farm.

[8] If a complementary effect exists this means that farm production is increased by a greater amount than by the extra production that would be achieved if the irrigated area were treated as a separate farmlet.

In reviewing the possible effect of irrigation on farm production, Waring[9] referred to research studies which showed that supplementing the diet of grazing cattle with concentrates or silage, failed to proportionally increase milk or meat production. Subsequently, in a review of observations on dairy cattle grazing habits in the North Coast area, Holder[10] indicated that stall feeding of either conserved roughage or concentrates reduced time spent in grazing by approximately ten per cent. However, allowing the cattle access to a fresh "strip" of a fodder crop (vetch) at a set time each day, did not alter total grazing time. The reasons for this difference are not clear, but it may not be valid to assume that cows will respond to irrigated pastures in the same way as they respond to concentrates.

Although Waring mentioned the possibility of achieving a complementary effect with irrigation and pasture improvement, by increasing stocking rates, and so achieving an improvement in year round utilization of pastures over the whole farm, he did not account for this possibility in estimating production gains. It will be suggested, however, that there is evidence of a complementary effect on some survey properties. This has resulted in production gains, substantially greater than those predicted by an analysis based on the assumption that the effect is a supplementary one. The overriding point here, is that the role of irrigation depends on the associated management changes. For this reason, it is necessary to assess all analyses of profit on an individual farm basis.

Waring[11] has also commented on the use of irrigation as a drought insurance. It will be suggested that the findings of this survey confirm his statement that the feeding of concentrates is a much more attractive alternative.

While the farmers were not formally questioned on their view of the role of irrigation, it is possible to summarize their attitudes by reference to the management changes that they have initiated to complement the irrigation programme. In Table 6, these changes are classified for the complete sample of properties. The changes considered were those of increased herd size and the establishment of improved pastures. In relation to herd size, the minimum increase included was a change of 10 per cent in herd numbers, while a minimum area of ten acres was the criteria of whether a pasture improvement programme had been established. It will be apparent that, on most of the survey properties, adoption of irrigation was associated with other major changes in farm management.

In the analysis of profit, because of the above considerations, no attempt will be made to specifically impute profits to irrigation. Instead, the pasture improvement/irrigation programme will be considered as a single major change in management, and profits will be estimated for this change.

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[9] Waring, *op. cit.*

[10] J. M. Holder, "Observations on the grazing behaviour of lactating dairy cattle in a sub-tropical environment", *Journal of Agricultural Science,* Vol. 55, part 2 (1960), pp. 261-267.

[11] Waring, *op. cit.*

TABLE 6

Management Changes Associated with Irrigation Programmes on the Sample Properties

Changes Initiated	Code *	Number of Farmers	
		Full Sample	Included in Economic Analysis
		No.	No.
Improved Pastures and Increased Herd Size	I.P. and I.H.	17	9
Increased Herd Size Only	I.H.	2	1
Improved Pastures Only	I.P.	5	5
Neither Change	N.C.	1	..
Total	..	25	15

* For economic analysis.

6. PROFITS ON THE SURVEY PROPERTIES

Method of Analysis and Assumptions

The profitability of the combined irrigation/pasture improvement programme on the survey properties is measured by estimates of annual net gains due to the programme. Annual net gains are defined by the traditional partial budget procedure of adding extra returns to costs saved and subtracting extra costs and income foregone. In this procedure it is necessary to convert all overhead costs to an annual cost.

Extra returns arise from sale of butterfat and use of skim for pigs. Costs saved may be due to reduction of the forage crop planting programme, or to reduced expenditure on concentrates. Extra costs include the overhead and operating costs of the irrigation plant, establishment and maintenance expenses for the improved pastures, the extra costs of increasing herd numbers and maintaining the increase, and overhead costs of fencing.

The extra costs may or may not include labour. In most instances it was found that existing labour was more intensively used and it was not appropriate to include a direct cost. Also it was not necessary to allow for income foregone in sideline activities following the introduction of irrigation on any property. Fifteen farms had adequate records for a profit analysis. To standardize the presentation, it is assumed that each farmer has been irrigating for no more than five years. Farms that have been irrigated for less than three years are excluded from the analysis. Results of the analysis will be presented subsequently in Table 7, Parts I and II. (See pages 234-237). Further details of assumptions and methods in deriving this Table are discussed below.

Farm Production

Production "with irrigation" is the average of farm production in the three years or, if possible, the five years to 1962-63. Production "without irrigation" is based on the average of farm production over at least three years and, if possible, the five years preceding the introduction of irrigation. However, these figures were corrected to take account of the effect of seasonal conditions on production. In other words they represent an estimate of the production of the property in the appropriate period to 1962-63 if the irrigation/pasture improvement programme had not been conducted. The method of correction was to use production on an unirrigated neighbouring farm, or a group of unirrigated farms in the same district, to give an index of seasonal conditions. Production before irrigation was then corrected by the expression $Pc = Pu. \frac{Wi}{Wo}$; where Pc is corrected average production; Pu is uncorrected average production; Wi is the average of the index in the appropriate period to 1962-63 and Wo is the average of the index over the appropriate number of years prior to the introduction of irrigation.

Butter Price

It is assumed that return per lb. butterfat is 4s. 6d. This is a conservative price with freight deducted, which includes deferred pay, equalization step-ups, and an allowance for use of skim milk in the piggery.

Costs Saved

Elimination of expenditure on concentrates was the main source of cost saving but on one farm (6) further savings were associated with a change from purchase to rearing of replacements.

Interest Rate

In all calculations the interest rate assumed is 6 per cent which is the current interest charge on overdrafts for rural loans.

Annual Cost of Irrigation

The annual overhead cost of the irrigation plant is calculated by use of a *capital recovery factor.* This factor gives a constant annual cost (S) for both the repayment of the principal of an original loan (P) and the payment of interest (i) accruing on the outstanding loan over the life of the investment (n). The expression is:

$$S = P\left(\frac{i(1 + i)^n}{(1 + i)^n - 1}\right)$$

$$= P \times \text{crf (capital recovery factor).}$$

In assessing the annual cost it was decided that a ten-year life was appropriate for sprinkler irrigation plants, in this area. Although such a plant may be retained and remain usable for a much longer period, factors such as obsolescence and changes in the ambitions of the farmer, suggest that to assume a ten-year effective life is realistic. Initial capital outlay was estimated from data provided by officers of the Water Conservation and Irrigation Commission.

The annual cost of fuel for the irrigation plant has been calculated, when possible, from the farmers' estimates of hours of usage or fuel consumed. When this information was not available it has been assumed that the plant was operated in accordance with the theoretical requirements discussed in Section 3 of this report. Other annual costs estimated include maintenance and oil.

Annual Pasture Cost

The annual pasture cost is divided into two components; an overhead cost for establishing and re-establishing the pasture and the maintenance cost. The initial pasture cost was set at a standard figure of £12 per acre for prepared seed bed and £9 per acre for "ripped and sown". From this initial cost, the annual maintenance cost appropriate for that farm was deducted and the remainder was considered to be the overhead capital outlay. This establishment cost was then converted to an annual cost by use of the capital recovery factor for the appropriate pasture life, assuming a 6 per cent interest charge. The maintenance cost was calculated separately for each farm.

Herd Increase Cost

Extra cows were valued at £40 and interest was charged at 6 per cent on this value. Annual replacement charge was assumed to be £4 per cow, which is based on a herd life of four years and a sale value of £24. This procedure is not consistent with the use of the capital recovery factor, but is realistic if it is assumed that the value of the cow drops suddenly at the end of its life. It is thus appropriate to charge interest on the full value of the extra cows each year. It was assumed that the extra herd size had little effect on the sundry costs associated with milking the extra cows and did not result in any major expenditure on extra milking equipment or for an improved cowshed.

Bloat Control

High costs were associated with bloat control on some properties. On these properties it was necessary to adopt a regular programme of spraying irrigated pastures, prior to grazing with an anti-bloat oil.

Labour

On only one farm (No. 4) was extra labour measurable by actual payments. But on four other farms (Nos. 5, 9, 10 and 11) introduction of irrigation permitted permanent occupation of an additional family member. On farms 5 and 9 the extra labour unit was permitting a substantial reduction in the work undertaken by the farm owner and £500 per annum was considered to be an appropriate allowance for the extra labour due to the irrigation and pasture improvement programme. On farms 10 and 11 the whole of the labour unit was attributed to irrigation and pasture improvement, and £800 per annum was allowed.

Machinery and Fencing Overhead

The annual cost of extra investment in these items was calculated using the appropriate capital recovery factor for each item.

ADDITIONAL FERTILIZER FOR UNIRRIGATED AREAS

On some farms development programmes included regular topdressing of pastures on the unirrigated sections of the farm. Costs associated with this aspect of development must be included in assessing the profitability of the over-all farm development programme.

Results

The results of the analysis of profitability is presented in the two parts of Table 7, which also includes details of effective farm area, area irrigated, area of improved pasture and production gains. The row listed as "code" refers to the classification of management changes described in Table 6. Thus I.H. represents increased herd size and I.P. a pasture improvement programme.

In interpreting the estimates of annual net gain or loss, given in Table 7, it is important to note that the costs of interest and depreciation (capital recovery) on extra capital have been included in the costing. Thus all cash and overhead costs have been allowed for and the net gain shown represents the amount available to compensate the farmer for the additional physical and managerial effort which he has had to devote to the new techniques. The additional effort involved cannot readily be measured. However, it appears that, under a typical irrigation/pasture improvement programme, the extra work load for the farm operator would be of the order of at least 400 hours per annum. In this connection it should be noted that extra labour is required for irrigation, pasture improvement, grazing management and milking.

It is likely, therefore, that the minimum labour reward, required by the operator, would be of the order of £200 per annum. This is, of course, a subjective matter, which will depend very much on the individual. However, the farms have been divided into three groups on the basis of this assumption.

Where the gain exceeds £200 per annum irrigation has probably been worth while. In the remaining instances showing a gain the attractiveness is doubtful, while in those showing a loss it is most unlikely that any hidden factor would indicate that the investment has been a wise one. In two instances showing a loss irrigation has probably resulted in retention of a son on the farm. But, even then, the income gain achieved has not warranted employment of the son at rates comparable with those that could be obtained through off-farm employment.

The profits achieved can now be related to:

(*a*) a hypothesis that a management system involving irrigation, pasture improvement and increased herd size will give profits;

(*b*) Waring's[12] argument concerning the high cost of irrigating areas of less than 15 acres; and

(*c*) the location of farms number 13, 14 and 15 in the Tweed Valley.

Of the five properties showing a profit of £200 or greater, number 8 did not have an increased herd size nor number 10 a pasture improvement programme. But on farm number 8 a build up in herd size had been completed, prior to the introduction of irrigation, by a management system

[12] Waring, *op. cit.*

TABLE 7

PART 1: *Analysis of Profit Associated with Irrigation and Pasture Improvement on Survey Farms—Farms Number* 1 *to* 8

Item	Unit	Farm Number							
		1	2	3	4	5	6	7	8
Effective Farm Area	Acres	250	240	350	260	160	170	210	200
Average Area Irrigated	Acres	12	10	26	30	40	25	25	25
Area of Improved Pastures	Acres	22	10	26	40	50	25	25	25
Code		I.H. & I.P.	I.P.	I.P.	I.H. & I.P.	I.H. & I.P.	I.P.	I.H. & I.P.	I.P.
Farm Production—									
Without Irrigation	lb. b'fat	7,180	4,830	10,350	8,250	6,750	9,100	6,750	11,360
With Irrigation	lb. b'fat	7,610	5,120	12,750	15,370	13,340	9,630	9,690	18,090
Increase	lb. b'fat	430	290	2,400	7,120	6,590	530	2,940	6,730
Extra Returns—									
Value of Extra Butterfat and Skim	£	97	65	540	1,602	1,480	120	660	1,520
Costs Saved—									
Concentrates	£	95	40	..	..	..	..	..	240
Other	£	..	..	..	..	..	300	..	..
Total Gross Gain	£	192	105	540	1,602	1,480	420	660	1,760

Extra Costs—										
Irrigation—										
Overhead	£	193	151	188	214	207	166	136	197
Operating	£	67	45	34	53	116	102	146	55
Pastures—									
Overhead (Establishment)	£	56	46	66	62	91	36	51	37
Maintenance	£	48	5	57	140	135	88	50	68
Herd Increase	£	76	..	50	84	168	..	84	..
Bloat Control	£	8	..	115	107	110	40	30	80
Labour	£	..	..	..	187	500	..	..	..
Machinery Overhead	£	..	..	118	280	238	197	4	5
Fencing Overhead	£	3	..	7	26	14	..	7	..
Additional Fertilizers for unirrigated Areas	£	..	..	..	..	..	..	..	..
Total Extra Costs	£	451	247	635	1,153	1,579	629	508	442
Annual Net Gain or Loss	£	−259	−142	−95	+449	−99	−209	+152	+1,318
Extra Capital at Replacement Cost	£	2,020	1,150	2,820	4,630	4,680	2,880	1,750	1,720

TABLE 7

PART 2: *Analysis of Profit Associated with Irrigation and Pasture Improvement on Survey Farms—Farms Number 9 to 15*

Item	Unit	Farm Number						
		9	10	11	12	13	14	15
Effective Farm Area	Acres	316	226	152	137	210	154	234
Average Area Irrigated	Acres	60	60	35	20	21	21	21
Area of Improved Pastures	Acres	60	60	35	20	20	21	18
Code		I.H. & I.P.	I.H.	I.H. & I.P.	I.H. & I.P.	I.H. & I.P.	I.P.	I.H. & I.P.
Farm Production—								
Without Irrigation	lb. b'fat	17,700	13,560	9,570	10,370	9,420	5,530	3,870
With Irrigation	lb. b'fat	22,430	25,810	21,050	15,300	10,960	8,530	6,590
Gain	lb. b'fat	4,730	12,250	11,480	4,930	1,540	3,000	2,720
Extra Returns—								
Value of Extra Butterfat and Skim	£	1,065	2,760	2,580	1,110	347	675	611
Costs Saved—								
Concentrates	£	..	..	..	..	..	..	..
Other	£	..	..	..	..	..	..	..
Total Gross Gain	£	1,065	2,760	2,580	1,110	347	675	611

Extra Costs—									
Irrigation—									
Overhead	£	199	227	178	222	51	163	109
Operating	£	157	131	112	117	31	42	23
Pastures—									
Overhead	£	38	38	54	23	49	28	21
Maintenance	£	174	174	88	66	48	50	79
Herd Increase	£	118	294	409	56	59	25	92
Bloat Control	£	..	5	..	..	1	5	..
Labour	£	500	800	800	..	..	..	..
Machinery Overhead	£	90	152	174	166	90	192	102
Fencing Overhead	£	..	..	..	..	..	..	..
Additional Fertilizer for Unirrigated Areas	£	171	307	..	..	..	36	..
Total Extra Costs	£	1,447	2,128	1,815	650	329	541	426
Annual Net Gain or Loss	£	−382	+632	+765	+460	+18	+133	+185
Extra Capital at Replacement Cost	£	3,650	4,990	4,770	3,200	1,450	2,750	1,650

involving substantial purchases of grain and hay in dry springs and droughts. Similarly on farm 10 the good response to irrigation of the naturalized white clover was atypical and the pastures irrigated could effectively be considered to be improved.

Of the farms showing annual net losses: on number 1 both herd size was increased and pasture improvement adopted, but area irrigated was only twelve acres; on number 2 only 10 acres were irrigated and herd size was not increased; on numbers 3 and 6 herd size was not increased; on numbers 5 and 9 herd size was increased and pastures improved but production did not increase sufficiently to cover the allowance included in the costing for employment of a son on the property.

Of the farms showing only small net gains, number 7 is comprised largely of steep hill country of low fertility. Thus most of the dairy production before the introduction of irrigation was derived from the limited areas of creek flat. There was therefore less scope for exploitation of complementary effects between irrigated and non-irrigated land. Also, of these farms, numbers 13, 14 and 15 are the only three in the Tweed valley.

Some mention should be made of the 10 properties not included in the analysis. Although results could not be carefully analysed it appeared that profits were substantial in at least four instances. Similarly there was at least one example where virtually no increase in production could be observed and several where the benefits from irrigation appeared unlikely to more than offset the cost involved.

The following conclusions appear valid.

(1) There is good evidence that a number of farmers have profitably adopted a management system involving irrigation, improved pastures and increased herd size.

(2) There is limited evidence that irrigation of small areas is not profitable.

(3) There is some indication that use of irrigation in the Tweed valley is less profitable than in the Richmond valley.

TABLE 8

Production Gains Per Acre Irrigated on the Survey Properties

Farm Number	Gain Per Acre lb. butterfat	Farm Number	Gain Per Acre lb. butterfat
1	36	9	79
2	31	10	204
3	92	11	328
4	237	12	246
5	165	13	73
6	21	14	143
7	118	15	130
8	269		

[12] Waring *Op. cit.*

Further reference should be made to production gains achieved on the sample properties. These are expressed as gain per acre irrigated in Table 8. It will be noted that five farms had production gains in excess of 200 lb. butterfat per acre irrigated.

This is believed to be evidence that a complementary relationship can exist between use of fodder produced on the irrigated area and utilization of feed supplies throughout the year over the whole farm.

7. ALTERNATIVES TO IRRIGATION

At the time of the survey, on the soil types where irrigation is economically feasible, the only major alternatives for increasing production by improving feed supplies in the critical spring period lay in concentrate feeding and the use of non-irrigated ladino clover pastures.

The economics of concentrate feeding are not clear but it is not thought that a similar complementary effect can be achieved. Concentrate feeding, appears a less profitable alternative to irrigation except when the farmers' only aim is to prevent losses in droughts and to keep the herd producing at a slightly higher level per cow in dry springs. Ladino pastures without irrigation are least productive when production from the improved area is most needed. If they do lift production levels they still make little contribution to stabilizing income and there is indeed little evidence that substantial profits can be achieved by their use as the sole component of a pasture improvement programme.

Over the last year promising results have been obtained on the red basaltic soils of the area with a feed year system in which feed supplies in the winter and spring are improved by use of subterranean clover and vetch, and the quality of summer and autumn feed supplies, is lifted by use of the sub-tropical species (*Glycine javanica*).[14]

The subterranean clover and vetch make good growth on the more reliable autumn rains and can be rationed out to the herd as a high quality supplement throughout the winter and spring until late October.

With evidence on the suitability of other sub-tropical species for the alluvial soils[15] and of the potential for use of ladino white clover, and oats to substitute for vetch on these soils it is now feasible to devise a similar feed year system for the alluvial soils of the region.

Where irrigation is already installed a complete feed year system will no doubt incorporate irrigated pastures as a major component. But at this stage, if an irrigation plant has not already been purchased, no conclusion can be made on whether provision of irrigated ladino pastures will add to

[14] J. G. Bird and F. G. Swain, "A Note on a Whole Farm Feed Year Project", this *Review* Vol. 32, No. 2 (June, 1964).

[15] J. G. Murtagh, P. T. Mears and F. G. Swain, "Forage Problems and Species Research in the Richmond-Tweed Region", in *Pasture Research for the Richmond-Tweed Region Far North Coast of N.S.W.* Proceedings No. 1, Tropical Grasslands Society of Australia. Feb., 1964.

profit. In this regard Henzell and Stirk[16] have referred to interactions between soil moisture, root depth and soil nitrogen level. It appears that growth of deep rooting sub-tropical grass/legume mixtures may be less restricted by moisture deficiencies in the late spring than is a ladino pasture.

8. CONCLUSION

It is concluded that the survey results show that there is a quite clearly defined system for profitably integrating spray irrigation into the general farm programme on many Far North Coast dairy farms. The elements of this system are the combination of irrigation with improved pastures and higher stocking rates.

It is also thought that, where conditions are suitable for irrigation, there is no proven alternative management system which is as profitable as the effective adoption of this programme.

As would be expected with any new technology, it was not found that irrigation has invariably been profitable. In fact the number of farms showing an annual net loss was substantial. It is believed, for this reason, that irrigation profits in the area are particularly sensitive to the managerial capacity of the farmer. This sensitivity is related to the relatively high overhead costs associated with irrigation, and to technical problems in maintenance of vigorous ladino clover pastures.

Although it is difficult to give specific evidence on each point, it is considered that important factors in achieving profits through good management are:

(a) the plant should be designed to irrigate at least fifteen, and, preferably, 20 or more acres;

(b) the area of pastures to be irrigated should be highly improved and kept that way by a regular programme of replanting;

(c) the farmer must be prepared each year to start irrigation as soon as moisture conditions warrant it;

(d) the farmer must be determined to use the plant as necessary for at least ten years;

(e) in most instances, efficient use of the pasture can only be made by increasing the size of the herd; and

(f) the plant must be of good design, so that labour and power requirements are low.

Of these points, (a) is based on the survey results. It is also obvious that there are high overhead costs when only small areas are irrigated. Another factor is the difficulty of maintaining a continuous supply of high quality pasture for a dairy herd of typical size with an area of less than ten acres. Intermittent supplementation would not be expected to be nearly so effective in lifting herd production.

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[16] E. F. Henzell and G. B. Stirk, "Effects of Nitrogen Deficiency and Soil Moisture Stress on Growth of Pasture Grasses at Samford, South-east Queensland. 2. Calculation of the Expected Frequency of Dry Periods by a Water-budget Analysis", *Australian Journal of Experimental Agriculture and Animal Husbandry*, Vol. 3, No. 11, (November, 1963).

Point (d) emphasizes the need to offset high overhead costs by frequent use of the plant and (f) is directed at factors in irrigation plant design which have an important bearing on farmers' annual decisions on when they should commence irrigating. (See also, Appendix 1).

Economists may be suspicious of the emphasis on technical efficiency in these conclusions. But this emphasis is clearly related to the need to spread overhead costs over a large production gain and also to considerations of plant physiology which are important in this area.

A further aspect of irrigation economics in the area is that profits appear to be lower in the Tweed Valley. In this area, spring rainfall is greater and more reliable, than in the Richmond River district. Also the problem of lack of persistence of ladino white clover pastures is more serious. In the Tweed valley, few of these pastures remain highly productive for more than two years. Thus costs are high, and there is a continuing problem of maintaining a satisfactory area of pastures with sufficient growth potential to warrant irrigation.

The survey results largely confirm the tentative theories on irrigation economics in the area that were presented by Waring.[17] The major point of difference is that we consider there is evidence that irrigation, *can* have a complementary effect on farm production.

It is concluded that there is need for continuing review of the farmer's choice between spending money on irrigation or spending it on extensive development with the new pasture species now available.

Finally it should be noted that there appears little scope for achieving profits from irrigation where the scheme also has to bear the high overhead cost of water conservation in conditions that do not give a very favourable excavation-water stored ratio.

Further articles are planned. It is considered that predictive budgets can be prepared for a range of assumptions concerning pre-irrigation farm resource situations and these will be the subject of one article. The final article will briefly discuss the development of an intensified extension programme aimed at improving farmer decision making in all aspects of irrigation farming under North Coast conditions. A central assumption will be that advice should depend on the managerial skill and particular circumstances of the individual farmer.

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[17] Waring, *op. cit.*

APPENDIX I

The Engineering Efficiency of the Irrigation Plants on the Survey Properties

Officers of the Water Conservation and Irrigation Commission conducted a study of the engineering and operational efficiency of the irrigation plants on nineteen of the survey properties. Results of this study indicate that many North Coast irrigators have inefficient plants. This finding is of significance in relation to:

(i) the economics of irrigation on individual properties when the plant is actually used. Operating costs are higher than necessary and efficiency of water application is lower;

(ii) the number of farmers who have irrigation plants and do not use them when a profitable return (over operating costs) could be obtained. This is believed to be associated with the deterring effects of high labour requirements and high operating costs.

In assessing efficiency, the existing irrigation plant was in each case compared to a plant designed to Water Conservation and Irrigation Commission standards for the circumstances that applied on the property. Table 9 presents a summary of the percentage difference in power consumption per acre between the existing and ideal plants. Details were sufficient for 14 properties.

TABLE 9

Inefficiency in Operating Costs of Irrigation Plants on the Survey Properties

Extra Power Requirement per Acre Inch as Percentage of Power Requirements for Water Conservation and Irrigation Commission Designed Plant	Number of Farms
Greater than 30 per cent extra power required	3
20-29 per cent extra power required	2
10-19 per cent extra power required	2
Approximately the same (+ 9 per cent to — 9 per cent)	6
Power requirement 10 per cent less than power requirement for W.C. & I.C. plant	1
Total Farms Included	14

The most inefficient plant required 50 per cent more power than the W.C. & I.C. design for that property. At the average rate of 2.4 pence per electrical unit, the extra cost for a single application of 1½ inches to 20 acres is £6 5s.

The capital cost of this plant was £400, or 26 per cent more than the capital cost of the W.C. & I.C. design.

Apart from high power costs, the most frequent faults are shown in Table 10.

TABLE 10

Further Faults with Irrigation Plants Surveyed for Efficiency

Fault	Number of Farms Specifically Mentioned
Excessive Labour Requirement	7
An Excessive Precipitation Rate	7
Uneven Ground Coverage	4

In addition to the faults mentioned in Table 10 there were plants with a pipe size that was too small, incorrect spacing of sprinklers and with the sprayline operating in the wrong direction (up and down the slope instead of across it).

A substantial saving in capital cost could have been made with four plants, but the Water Conservation and Irrigation Commission designs were somewhat more expensive in other cases and over-all there was little difference in capital outlay for the existing and the recommended plants.

APPENDIX 2

Assistance Available from the Water Conservation and Irrigation Commission

Provision is made under the Farm Water Supplies Act (1946) to aid landowners in the development of water supplies on individual farms or groups of farms for domestic, stock or irrigation purposes. A full explanation of this Act is given in the pamphlet *Enough Water*, which may be obtained on application to the Water Conservation and Irrigation Commission of New South Wales, Box 2708, G.P.O., Sydney.

Among other things the Act provides for:

(*a*) farmers to be given technical assistance, including the preparation of working drawings and specifications; and

(*b*) advances for farm water supply purposes to be granted, at low rates of interest, through the Irrigation Agency of the Rural Bank of New South Wales.

The Act covers schemes both on individual farms and groups of farms.

APPENDIX 3

An Early Assessment of the Role of Irrigation on North Coast Dairy Farms

(An extract from *Farm Life on the Richmond and Tweed Rivers*, compiled by F. Russell and published by John Sands and Co., 1906, page 42.)

"Irrigation.

This is a question that the Richmond River farmer has hitherto taken very little interest in, owing to the fact that the Richmond has been blessed with a good rainfall. It has been considered that irrigation was quite unnecessary but the experience of the last few years has led many to turn their minds to this subject, and a few of the more enterprising residents have experimented on a small scale.

"It seems to be against human nature for one to profit by another's experience, and Australia is particularly slow in learning the value of irrigation. There is no lack of object lessons. A visit to California would satisfy even the most prejudiced man as to the miracles it has wrought in that State. The condition of things in Australia today is similar to what it was in California 20 years ago before money was invested there in irrigation. In Southern California for the last 10 years, rainfall has not exceeded an average of 5 to 6 inches per annum, and from that district now is produced some of the finest fruit that is grown. In a country as extensive as Australia, the conditions, of course, vary considerably, and on the Richmond River it would certainly not be wise to embark on any large irrigation scheme. But even in this well watered district there are dry spells as the dairy farmers know to their cost and a patch of irrigated land in these times would be a little goldmine to the dairy farmer. The district is well favoured as regards the water supply, and there are very few farms where it would not be practicable to have a small pumping plant and irrigate a few acres. A patch of from 10 to 20 acres of irrigation plant should be regarded in the light of an insurance policy. Prudent men nowadays insure their lives for the benefit of their families, and they insure their houses and furniture against fire, and an irrigation plant is undoubtedly one of the best forms of insurance policies that any farmer can invest in.

"We mentioned just now that some of the residents were waking up to the value of irrigation. One of our enterprising farmers, Mr. Whitney of South Gundurimba, recently invested in an irrigation plant which is shown in the accompanying photographs. Messrs. Buzacott & Co. Ltd., of Sydney, a firm who have devoted a great deal of attention to irrigation, were entrusted with the order, and the plant was installed by their local representative, Mr. Jas. Gibson. The engine is a 6 horse power 'Hercules' Oil Engine, driving a 3 inch Centrifugal pump. The water is being raised a vertical height of 40 feet from the river, and 10,000 galls. per hour are being pumped. After the water is raised to the necessary height the question of distribution comes in, and this is a fine art, for unless the water is economically distributed it is apt to be wasted. The land to be irrigated very often is uneven, and the farmer, whilst willing to invest money in a plant, hesitates when he considers the cost of levelling the ground. In Mr. Whitney's case a very ingenious device was adopted, the water being pumped through galvanised-iron piping, in which, at regular intervals, are placed sprays—an invention of Mr. Nunan. The water from these sprays covers an area of ground 40 feet in diameter, and the plant pumps the equivalent of 1 inch of rain over four acres per day. This invention has solved the problem of distribution of water, and it has this advantage over the ordinary methods of distribution by gravitation that it is the nearest possible approach to natural rain, for in its descent it becomes aerated. Mr. Whitney speaks in very high terms of this plant, and is more than satisfied with his investment".