INTEGRATED PART-FARM IRRIGATION IN THE UPPER DARLING AREA OF NEW SOUTH WALES

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1. SUMMARY

In the past five years, there has been a conspicuous increase in the number of integrated part-farm irrigation schemes in the Upper Darling Region of New South Wales. The main characteristics of 26 such schemes are described in this article.

Evidence remains of a number of older irrigation installations along the Darling River. Some suggestions are made about the reasons why these earlier schemes failed. These are—

(*a*) Failure of returns to justify the cash and opportunity costs,

(*b*) Increasing labour costs,

(*c*) Erratic water supply,

(*d*) The effects of occasional, severe flooding, and

(*e*) Agronomic problems.

Several of these factors are still operative, and may cause difficulties with the present schemes.

Mention is made of the types of pasture and fodder crop production which are being undertaken. Many of the schemes are basing production on *Sorghum almum* but soil structure and fertility problems are likely to be encountered with this species unless suitable pasture rotations are devised.

In general, there are two alternative uses for irrigated pasture and fodder crops in such a region,

(i) Increased production stability by the use of "on-farm" or "off-farm" integration, or

(ii) The introduction of new forms of production.

The application of these alternatives in the Upper Darling Area is discussed. On a typical property, a relatively small area of irrigation could be used for the following purposes, depending on the seasonal conditions:—

(*a*) Survival feeding of high value stock during a drought.

(*b*) Using irrigated pastures to give an assured spring lambing, raising lambing percentages by as much as 40 per cent and allowing excess stock to be sold.

(*c*) Allowing rapid fattening of young cattle bred on the property.

(*d*) Allowing regular purchase of store cattle for fattening on summer fodder crops.

The above proposals are examined in some detail.

A number of small enterprises near Brewarrina, Bourke and Wilcannia are engaged in the production of lucerne hay for sale. With average prices at £15 to £25 per ton, this represents an attractive proposition.

The most important factor in the success of integrated part-farm irrigation in the Upper Darling Region is to maintain a flexibility of approach to match the seasons.

2. INTRODUCTION

In recent years there has been some revival of part-farm irrigation in the northern part of the Western Division of New South Wales. Old pumps along the Darling River and elsewhere, and the outlines of old irrigation layouts and old farming equipment remain as evidence of the interest displayed in irrigation in the early days of land settlement in this area.

The most important sources of water for these schemes, both past and present, is the Darling River system. This includes such streams to the north as the Paroo, Warrego, Culgoa, etc. (see Fig. 1). Some private dams have been constructed on these northern rivers to improve the water supply. By far the majority of the schemes, however, rely on the Darling River itself. The subsequent discussion will be mainly directed towards these schemes, although the same principles will apply to others in the region. Where private dams are involved, capital costs of development are, of course, increased.

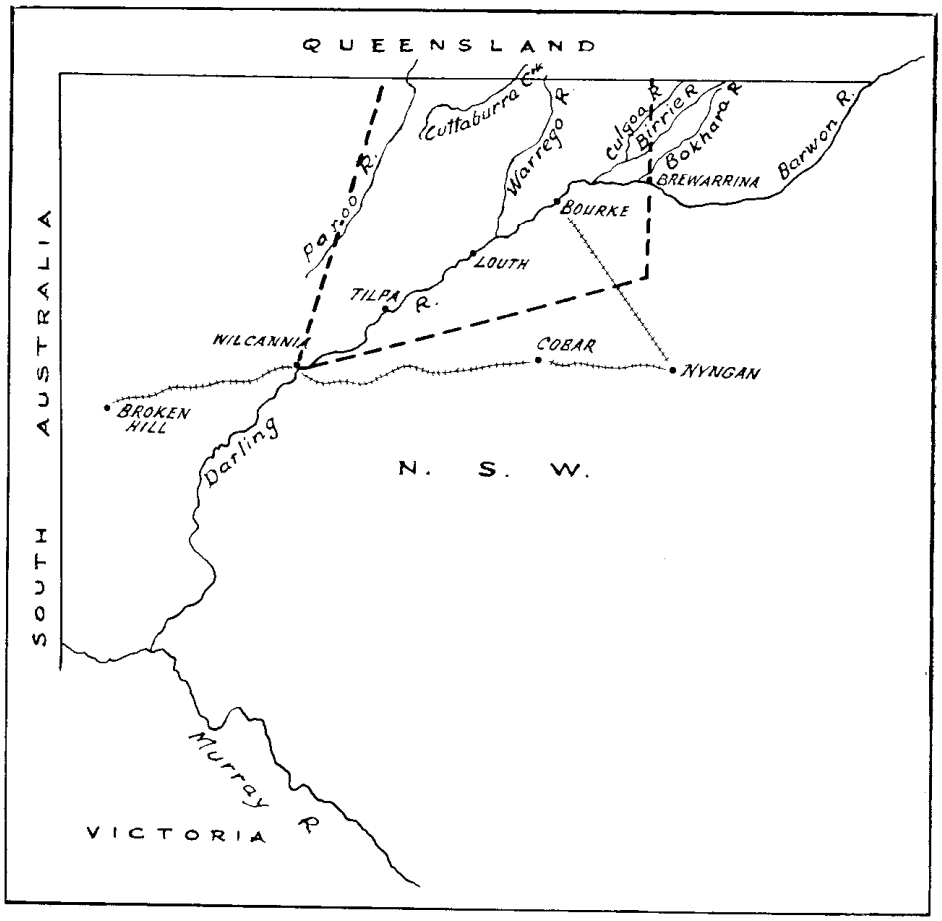

Fig. I—Location Map of the Upper Darling Area of New South Wales.

The main characteristics of the development on twenty-six properties along the Darling River between Brewarrina and Wilcannia are given in Table I. Of these, fourteen are planning some expansion. Only those properties where definite developmental work was in progress, such as cleaning, pump installation, channels, etc., have been included in the "areas-proposed" section. Other graziers with river access are planning to irrigate but are awaiting the results of those schemes already in operation before taking any definite action.

This survey covers the majority of schemes engaged in pasture production along the Darling River between Brewarrina and Wilcannia and was completed in December, 1961. Several installations growing citrus and vegetables are in operation near the principal towns along the Darling, but they have been excluded.

TABLE 1

Characteristics of 26 Irrigation Schemes on the Darling River between Brewarrina and Wilcannia

A. Integrated Part-farm Irrigation

Property Number	Total Area Under Irrigation (Acres)	Area Established (Acres)	Area Proposed (Acres)	No. Years in operation	Previous Irrigation Experience
1	400	400	..	2	Yes
2	400	400	..	1	Yes
3	120	20	100	4	No
4	120	20	100	1	No
5	100	..	100	..	No
6	50	..	50	..	No
7	45	5	40	1	Yes
8	45	5	40	2	No
9*	40	20	20	2	No
10	40	10	30	2	No
11	38	3	35	2	No
12	25	5	20	2	No
13	20	20	..	1	Yes
14	15	10	5	20	No
15	5	5	..	2	No
16	5	5	..	2	No
17	4	2	2	5	No
18	2	2	..	2	No
19	2	2	..	2	No
20	2	2	..	4	No

B. Irrigation for Sale of Hay (Usually Lucerne)

21	70	..	70	..	Yes
9*	40	20	20	2	No
22	20	20	..	5	Yes
23	10	10	..	1	No
24	6	6	..	5	No
25	5	5	..	3	No
26	3	3	..	2	No

* This property appears in both sections, as the total production at present is being sold for capital development. In the future, the owner intends to establish a drought reserve, and then sell off excess production.

In Table I the irrigation schemes have been divided into two types: those where a form of "on-farm" integration as defined by Rutherford[1] is intended and those where the irrigation is primarily aimed at producing hay for sale. These latter are nearly always small irrigation leases near the major towns such as Brewarrina, Bourke and Wilcannia and a significant proportion of the total lease is usually under irrigation. In the case of the former, Merino wool production is the main enterprise, and the irrigation is subsidiary. Property sizes vary from about 15,000 to 120,000 acres and there is always a large disparity in size between the irrigated portion and the rest of the property. This represents a different situation to that studied by Rutherford in the Southern Murray Basin where the irrigated and dryland portions of the properties are generally more nearly equal.

[1] J. Rutherford, "The Integration of Irrigation and Dryland Farming in the Southern Murray Basin", this *Review*, Vol. 26, No. 4 (December, 1958).

Of the twenty-six irrigators interviewed, only six had had previous irrigation experience before developing their present schemes. The successful operation of the irrigated portion of the property calls for a separate set of managerial skills than those required to operate the dryland portion successfully.[2] In an area such as the Upper Darling Area where there is no tradition of successful irrigation in the past, the lack of these managerial skills to run both portions of the enterprise as well as successfully integrate the two, is likely to severely limit the successful irrigation development. A similar situation has been described by Schaffner[3] in his study of the problems facing partial irrigation development in North Dakota.

Another point worthy of note is the very recent origin of nearly all of these schemes. The oldest included in Table I, over twenty years old, is of relatively small size. By far the majority have commenced in the last two to five years. Although as mentioned above, evidence of earlier schemes, some dating back nearly to the last century can be found along the river, the above is the only one still in operation. On some properties with irrigation at present, evidence of earlier schemes remains but the present schemes are entirely unrelated both in management and design.

It is perhaps profitable to speculate on the reasons why these earlier schemes failed. Many of the factors responsible may still be operative, although changed economic conditions and technical improvements have possibly made part-farm irrigation a more attractive proposition by now. It is suggested that the following factors were of importance:—

Failure of Returns to Justify the Cash and Opportunity Costs

The problem of obtaining adequate financial returns in an area remote from markets is still of prime importance, and will be dealt with in more detail later.

Increasing Labour Costs

As well as the high labour inputs per acre necessary for irrigation in the best of circumstances, many of the earlier schemes were powered by steam or gas induction engines. Both types were wood burning and had high labour requirements for fuel cartage. The advent of modern diesel and electric power has rendered these types obsolete.

Erratic Water Supply

The Darling River is notoriously erratic in flow, and while adequate volumes of water are available when the river is high, occasionally the flow may be reduced to a mere trickle. Also, the quality of the water may be unsuitable for irrigation during low rivers, particularly towards Wilcannia. With an increase in the number of pumps, this variation in flow could well increase, although the scheme to provide a number of weirs in the river is aimed at making more water available for irrigation.[4]

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[2] J. Rutherford, *op. cit.*

[3] L. W. Schaffner, *An Economic Analysis of Proposed Irrigation in Northern North Dakota,* North Dakota Agric. Experiment Station, Bulletin 404 (September, 1956).

[4] Water Conservation and Irrigation Commission of N.S.W., *Water Conservation and Irrigation in New South Wales,* Govt. Printer, Sydney (undated).

The Effect of Occasional Severe Flooding

Occasional, severe floods such as were experienced in 1950, 1955 and again in 1956 caused severe damage to any installations in operation at the time. Often, pumping sites above extreme flood level are difficult to find as are suitable irrigation sites. Many of the present installations are susceptible to damage by extreme floods.

Agronomic Problems

Several graziers who were associated with some of the earlier schemes have stated that pasture and crop production often failed after about the third year on any one piece of land. This could have been associated with drainage problems, salinity problems or soil mineral deficiencies. There has been no evidence of this trend to date in the present installations.

3. PASTURE AND FODDER CROP PRODUCTION

The revival of interest in irrigation in the Upper Darling Region coincides with the rapid increase in popularity of *Sorghum almum* in New South Wales since its release in 1959. Accordingly, many graziers are basing their irrigation development on this species mainly under flooding. Very little information is available as yet about its long term behaviour under irrigation in this region, as the oldest stand was established in November, 1960. Nevertheless, it is clear that, in company with the other fodder sorghums, this species must be regarded as a fodder crop rather than a pasture.

It is unlikely that a system of fodder cropping using this species alone would be successful without heavy applications of nitrogenous fertilisers at a relatively high cost per unit of nitrogen.[5] Some form of crop rotation involving pastures or leguminous fodder crops will have to be evolved to maintain soil fertility and structure if *Sorghum almum* is to form the basis of the fodder production.

The other most important species is lucerne which is usually quite satisfactory when grown under spray irrigation. However, under flooding and in inexperienced hands, problems of land grading and scalding are likely to occur.

Few of the irrigation schemes included in this survey, have grown species other than the above. Fodder crops such as oats, rape, and Japanese millet have been tried on several properties, often when preparing land for *Sorghum almum*. As mentioned above the use of pastures as well as fodder crops will become necessary from the soil fertility point of view. However, this is an agronomic problem and need not be discussed here. It suffices to say that the type of pasture and fodder crop development is linked with the class of animal production enterprise intended, i.e., fat lamb production is often based on annual winter pastures.

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[5] Donald has reviewed the relative merits and costs of using fertilizer and legume nitrogen in pasture production. C. M. Donald, "The Impact of Cheap Nitrogen", *The Journal of the Australian Institute of Agricultural Science,* Vol. 26, No. 4 (December, 1960).

4. ALTERNATIVE USES OF IRRIGATION

Rutherford has discussed the alternative uses of irrigation in semi-arid areas.[6] In general terms, there are two alternatives:—

(i) Increased production stability by the use of "on-farm" or "off-farm" integration. This implies the use of irrigation for fodder production to reduce production uncertainties, without changing the structure of the original enterprise.

(ii) The introduction of new forms of production, i.e., fat lambs or dairying into a merino wool area.

Willoughby has advocated the use of irrigation waters to reduce production uncertainties in the merino wool industry. The following extract is quoted from his paper[7]:—

"Quite a degree of stabilisation (in the wool industry) would be afforded if cheap pasturage and fodder could be provided to supplement the deficiencies of the native pastures. To a large extent, this could be done by giving the industry a major share in the water which has been conserved by national expenditure."

Willoughby goes on to point out that, as the total water supplies are limited, a high degree of efficiency is necessary to enable the benefits to reach as large a section of the grazing community as possible. However, this proposal is only dealt with in very general terms, and no attempt is made to discuss the practical and economic difficulties involved.

New enterprises which can be undertaken in such an area, remote from markets and centres of population, are limited. Any form of resource development undertaken would probably involve fat lamb raising, vealer production or fattening store cattle. The latter should not strictly be included in this section, as it is often undertaken without irrigation, in good seasons when the market is suitable. At present, it is difficult to suggest high value cash crops which are suitable for this area, and which can be marketed satisfactorily.

5. APPLICATION IN THE UPPER DARLING REGION

In practice, it is rather difficult to separate these alternative uses of irrigation. For example, consider a property running merino sheep for wool production, breeding its own replacements, and running a few beef cattle (breeding cows), the typical situation in the area. With an irrigation plant, and using suitable combinations of pasture and fodder crops, some or all of the following uses are possible depending on seasonal conditions:—

(*a*) Survival feeding of high value stock during drought.

(b) Using irrigated pastures to give an assured spring lambing, thereby raising lambing percentages by 40 per cent or more, and allowing excess stock to be sold.

(*c*) Allowing rapid fattening of young cattle bred on the property.

(*d*) Allowing regular purchase of store cattle for fattening on summer fodder crops.

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[6] J. Rutherford, *op cit.*

[7] W. M. Willoughby, "Irrigation and the Wool Industry", *The Journal of the Australian Institute of Agricultural Science,* Vol. 10, No. 3 (September, 1944).

The irrigation is thus used for both the reduction of production uncertainties (drought feeding, increased lambing, beef production) and the introduction of a new form of production (fattening stores) without any extensive changes in the management or the class of stock run.

Survival Feeding During Drought

There are two possible approaches to drought feeding using irrigation:—

(i) To store the production from a relatively small area as hay or silage. As silage is rarely used in the area under discussion it will not be considered here.

(ii) To have a sufficient area of irrigation to support a significant proportion of the total stock during times of drought, the irrigation area being used for other purposes during most seasons. The main objection to this approach, as opposed to (i) above is that water for irrigation may not be available just when it is required.

The former approach is used by the majority of the owners of the smaller installations described in Table 1. Only very small areas of several acres (usually lucerne) are involved, and the aim is to build up a small hay reserve for feeding high value stock such as rams or stock horses. Often this could hardly be classed as "survival" feeding as the stock concerned are fed even in relatively good seasons to keep them in good condition.

Lloyd has studied the economics of conservation of pasture hay for drought feeding on the Southern Tablelands.[8] In general, it is uneconomic, unless a high level of technical efficiency is attained, and the stocking rate is increased using seasonal feeding, so that the overall drought risk remains the same. Conditions in the Upper Darling Region, differ in several important respects.

(i) Capital and running costs of the irrigation plant are additional to the conservation costs quoted by Lloyd.

(ii) The net return per sheep is possibly lower under western conditions, with increased overhead although it is difficult to obtain accurate figures. Waring quotes a Cobar grazier as returning as little as 15s. per head per annum for wethers.[9]

(iii) Droughts are erratic in nature, and there is no marked seasonal feed shortage as on the Southern Tablelands.[10]

(iv) Increased feeding out costs under the more extensive conditions.

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[8] A. G. Lloyd, "Fodder Conservation in the Southern Tablelands (1)", this *Review*, Vol. 27, No. 1 (March, 1959).

[9] E. J. Waring, "Drought Strategies and Resource Valuation in Pastoral Areas", this *Review*, Vol. 28, No. 3 (September, 1960).

[10] The seasonal rainfall incidence is slightly in favour of the summer, but the rainfall effectiveness is then lower, with the higher temperatures and evaporation. The result is a higher probability of green feed being available in the winter, but there is no marked seasonal feed shortage. Commonwealth Bureau of Meteorology, "Results of Rainfall Observations Made in New South Wales, 1948 (Commonwealth Government Printer).

Bearing these factors in mind, it is questionable whether the regular conservation of hay from irrigated pastures for drought feeding, except for high value stock would be economic. If the irrigated portion of the property is large enough to carry a significant proportion of the total number of stock during a drought, it may well be a different proposition. With the onset of drought conditions high value stock could be placed on the irrigation, thus ensuring their survival and at the same time reducing the burden on the rest of the property.[11]

This type of approach is preferable to attempting to provide a supplement for a greater number of stock by allowing limited access to the irrigated pastures. Animals have a known tendency under such conditions to "hang" waiting for the highly palatable supplement to appear. They then do not search for feed in the dry native pastures and the total nutrient intake is lower than before the supplement was provided.[12]

Assured Spring Lambing

In general, lambing percentages of merino sheep in the pastoral zones of New South Wales are low; of the order of 65 to 69 per cent. Ewes are expected to lamb under extensive conditions with a minimum of supervision and often only a relatively small proportion of the lambs born are reared. Seasonal conditions are also important and either mating or lambing during periods of feed shortage is associated with low lambing percentages.[13]

The majority of graziers in the Upper Darling Region tend to lamb "with the seasons". That is, whenever good rains occur with an expectancy of good feed being available for some months, the rams are put out. In addition, particularly towards Wilcannia, the tendency is to aim at a late autumn lambing as there is a higher probability of green feed being available during the winter months.[14] If this is achieved, it means that mating occurs during the summer, when the fertility of the merino is at its lowest.[15]

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[11] A good example of this approach came to notice in 1961. A mob of 3,000 old ewes dropped about 2,800 lambs in dry conditions in early September. Throughout September and early October conditions further deteriorated and the lambs went back and started to die. The owner then weaned them at six weeks of age on to about 300 acres of irrigated oats, cereal rye and *Sorghum almum*. The result was, about 2,600 of the lambs were saved and the ewes picked up as soon as the lambs were taken from them and could be sold. Without the irrigation, perhaps 75 per cent of both the ewes and lambs would have been lost.

These stock could be valued at, say, 2,600 lambs at 40s. per head and 3,000 old ewes at 25s. per head, or a total of £8,900. Without the irrigation, probably 75 per cent of them would have been lost, and so the gross return attributable to the irrigation would be £6,675 for a short period of about four months.

[12] G. L. McClymont, "Response of Stock to Supplementary Feeding on Pastures", *Proceedings of the Australian Society of Animal Production,* Vol. 1 (1956), p. 63.

[13] R. B. Dun, "Breeding Merino Sheep for Higher Lamb Production", *Wool Technology and Sheep Breeding,* Vol. VIII, No. 1 (July, 1961).

[14] See Footnote 10.

[15] R. B. Dun, *et. al.,* "Annual Reproductive Rhythm in Merino Sheep Related to the Choice of a Mating Time at Trangie, Central Western New South Wales, *Australian Journal of Agricultural Research,* Vol 11, No. 5 (September, 1960).

All in all, the average percentage of lambs reared in the Upper Darling Area is probably appreciably lower than the figures quoted above, and may be of the order of 40 per cent.

With the judicious use of pasture and fodder crops, the irrigation could be used to give an assured spring lambing for at least part of the breeding flock. Where this practice is followed both ewes and rams are put on the irrigation area some weeks prior to mating in March-April to ensure that both are in rising condition. Mating is also carried out in the irrigation where close supervision can be mantained. The ewes are then put out on to native pastures until about a month before lambing when they are brought back to the irrigation. This is to ensure that they experience good conditions at lambing and up to weaning. The ewes are then put out again and the weaners retained for some time on the irrigation.

Higher stocking rates than permissible for fat lamb production could be used, as the intention is to feed to obtain maximum growth and survival and not to fatten the lambs for sale.

Dun *et al* at Trangie have shown that increases of up to 33 per cent of lambs weaned can be obtained in favour of spring lambing over autumn lambing with merino sheep.[16] Using irrigated pastures and fodder crops as outlined above, it would not be unreasonable to expect average increases of 40 per cent or more in the number of lambs reared compared with results of the present "lambing with the seasons" under extensive conditions.

Some estimate can be made of the returns using this type of approach. If we assume that a property has 100 acres under flood irrigation and that this can be stocked at 16 ewes per acre under the above conditions, or a total of 1,600 breeding ewes can be transferred to the irrigation area. If the percentage of lambs reared is increased by 40 per cent over the lambing expected under dryland conditions, the gross return attributable to the irrigation would be 640 lambs at say 40s. per head or £1,280. If we asume that they are on the irrigation for a total of 6 months (2 months in the autumn and 4 months in the spring and summer) ; the water applications during this period total 30 acre inches at 5s. per acre inch[17] the total running costs for this period would be £750, and the net return £530. If the capital investment was £30 per acre to develop the irrigation this represents a return of 17 per cent in 6 months.

Topping Off Beef Cattle

On many properties in the Upper Darling Region, a small number of beef cattle are run for breeding purposes. During good seasons, the progeny are sold when fat. However, in many seasons, the stock are not quite ready for market, and a relatively short period on irrigated pastures would enable them to be marketed at an earlier age. It is difficult to attribute costs and returns of this type of activity, as the returns very much depend on the market conditions at the time. However, in certain specific situations it is likely to yield adequate returns.

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[16] R. B. Dun *et. al., op. cit.*

[17] J. F. P. Edmunds, "Relative Costs of Flood and Spray Irrigation", N.S.W. Department of Agriculture, *Irrigation School Handbook,* 1961, Processed, p. 124.

FATTENING STORE CATTLE

As mentioned earlier, many of the graziers are basing their irrigation production on *Sorghum almum* initially. Perhaps the main reason for this is the spectacular yields which can be obtained in a relatively short time, using this species. Griffith Davies and Edye record a dry matter yield of 5 tons 17 cwt. per acre under dry land conditions in Queensland, 12 weeks after planting.[18] It should be possible to equal or even exceed such yields under irrigation in the Upper Darling Area.

This species is very tall and coarse growing, and is more suitable for cattle grazing than sheep, although stocking to give efficient utilization is often difficult. Many of these graziers intend to use the *Sorghum almum* either for "topping off" cattle bred on the property as described above, or for fattening store cattle obtained in Queensland. Green lot feeding may be profitable under these conditions depending on the state of the cattle market at the time. However, a high capital outlay in the form of yards and bulk handling equipment is necessary even though it gives higher efficiency of feed utilization than grazing. A ready outlet for fat stock is available at the Bourke meatworks.

Irving in South Australia has studied the fattening of northern store cattle on winter improved pastures. His conclusions that young stock have distinct advantages for fattening would still apply when buying Queensland cattle for fattening on irrigation in the Upper Darling Region.[19] These advantages may be enumerated as follows:—

(i) Lower freight costs.

(ii) Greater efficiency in converting fodder to flesh, and higher stocking rates, i.e., a 1,000 lb. steer needs about 130 lb. of pasture to make the same weight gain as a 6,000 lb. steer using 80 lb. of pasture.

(iii) Equal weight gains with older stock. Weaners gained an average of 391 lb. over a period of 210 days, while 18 month steers gained 346 lb.

(iv) Higher price per lb. of flesh gained during fattening. In recent years, the margin between fattened weaners and 18-month steers has been at least £1 per 100 lb. dressed weight in favour of the weaners.

It is rather difficult to get accurate stocking rate figures for fattening on irrigated *Sorghum almum*. However, Griffith Davies and Edye record graziers fattening two beasts per acre under dry land conditions in north-western New South Wales and southern Queensland under good seasonal conditions.[20] It should be possible to duplicate or exceed this figure under irrigation in the Upper Darling Area.

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[18] J. Griffith Davies and L. A. Edye, "*Sorghum almum Parodi*—A Valuable Summer Growing Perennial Grass", *The Journal of The Australian Institute of Agricultural Science*, Vol. 25, No. 2 (June, 1959).

[19] M. R. Irving, "Fattening Northern Store Cattle", *Journal of Agriculture South Australia*, Vol. 65, No. 4 (November, 1961).

[20] J. Griffith Davies and L. A. Edye, *op. cit.*

Assuming two beasts per acre can be carried on irrigated *Sorghum almum* and weight gains of 1½ lb. per day[21] are maintained for four months, the total production of beef per acre above maintenance requirements would be 360 lb. At a price of 160s. per 100 lb. liveweight this represents a gross return of about £28 per acre assuming that the price per 100 lb. of fat and store cattle is the same. With a marked price differential in favour of fat cattle, higher returns would be expected.

Assuming that the total watering over this period is 40 acre inches, at a cost of 5s. per acre inch quoted above, the total watering cost would be £10 per acre. Further, if we admit handling and market charges of £5 per beast, the net return per acre would be £8 or a return of 26 per cent on the capital investment over four months, assuming a capital cost of £30 per acre.

Lucerne Hay Production for Sale[22]

A number of small enterprises, mostly of the order of 3 to 10 acres near Brewarrina, Bourke and Wilcannia are engaged in the production of lucerne hay for sale, and several larger schemes are being developed (see Table 1).

In the hot, dry climate of the Upper Darling Region, lucerne can be rather difficult to manage under flood irrigation, and care must be exercised to avoid scalding. Better results are usually obtained with sprays, which are used in the majority of cases.

The average production under irrigation from these areas is of the order of 8 tons per acre per year and the total production is sold locally. Prices range from £15 to £25 per ton, depending on the relative price of hay in the other hay-producing areas such as Dubbo and Wellington. Local prices are usually equal to or slightly below the price of hay landed at Bourke.

Edmunds, and the Bank of New South Wales have estimated the costs of spray irrigation and 9s. per acre inch of water applied will be used here.[23, 24] In the Upper Darling Area, dependence on natural rainfall is virtually nil and water applications are of the order of 8 to 10 acre inches between cuts, or 60 to 70 acre inches for the growing season.[25] Assuming that each cut results in 1 ton of hay per acre for a water application of 8 acre inches, watering costs would be £3 12s. per ton.

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[21] M. R. Irving, *op. cit.*

[22] This is actually a form of "off-farm" integration as described by J. Rutherford, *op. cit.*

[23] J. F. P. Edmunds, *op. cit.*

[24] Bank of New South Wales, *Spray Irrigation of Pasture and Fodder Crops,* Sydney, August, 1960.

[25] This figure is based on discussions with irrigators at Bourke. The usual thing is to apply three waterings each of about 3 inches between cuts, but accurate records are not available. The transpiration ratio of lucerne is usually given as 900 parts of water to produce one part dry matter of lucerne. (K. H. W. Klages, *Ecological Crop Geography,* Macmillan, New York, 1942, p. 177.) Therefore, the amount of water transpired to produce 1 ton of lucerne hay (90 per cent moisture, and assuming 1 ton per acre is obtained per cut) is about 8 acre inches which agrees very favourably with the above.

Several estimates of the costs associated with hay making are available,[26, 27] and the figures for the Southern Tablelands published by Lloyd[28] will be used here. It is assumed that there is no great variation in cost between conserving pasture hay on the Southern Tablelands and lucerne hay on the Upper Darling. It is significant, however, that Lloyd's cost analysis is based on the operator owning a full set of new equipment, and this may be far from the case in the Upper Darling Region where much second-hand or borrowed equipment is used with a resultant marked effect on costs.

The total cost of production of lucerne hay per ton in the shed can be estimated as follows:—

	Per ton £ s. d.
Irrigation costs	3 12 0
Conservation costs	6 5 0
Total	£9 17 0

With the prices quoted above of £15 to £25 per ton, this represents an attractive proposition.

The market at present is rather limited and Bourke, the largest centre, would only absorb about 300 tons per year of the locally produced hay. If local production increased to any great extent, some fall in price could be expected, and it would not represent such an attractive proposition.

6. GENERAL CONCLUSIONS

Several situations have been examined above suggesting how a relatively small area of irrigated pastures and fodder crops can be successfully integrated with dryland production in the Upper Darling Area without changing the present structure of merino wool production on the individual properties.

The costs and returns quoted above have only been intended as examples and no attempt has been made to take the many variables into account. Insufficient actual figures are available from the area at present to enable detailed cost analyses to be carried out and published figures have been used, or estimates made on theoretical grounds. Where watering costs are given, these are total costs, including fuel, labour, interest, etc., calculated on an acre-inch basis from published figures. Often, the only ones available were from entirely different districts and are little more than informed guesses when applied to this area.

The different ways of utilizing the irrigated pastures and fodder crops have been considered separately. It is emphasized that, in an area where variability is the main feature of the climate a flexibility of approach to

[26] Anonymous, "Harvesting Machinery for Hay and Silage", *Power Farming*, Vol. 62, No. 12 (December, 1953).

[27] D. H. Penny and F. G. Jarrett, "Costs of Fodder Conservation on Murray Swamps Dairy Farms", *Journal of Agriculture of South Australia*, Vol. 60, No. 7 (February, 1957).

[28] A. G. Lloyd, *op. cit.*

match the seasons is a necessary consideration. Depending on seasonal conditions, the production from the irrigation area could be put to one or more of the uses described above in any one year. Suitable combinations of pastures and fodder crops to allow this flexibility would have to be grown and irrigation based on one crop such as lucerne would not be suitable for this purpose.

As Waring has pointed out,[29] it is not sufficient for returns to exceed costs and to realize a reasonable return on the capital outlay. For part-farm irrigation to be economic, the returns must exceed the opportunity costs involved in diverting capital and managerial effort from conventional station improvements such as fencing, watering places and improved stock husbandry.

On several properties the irrigation pump serves a dual purpose. A channel is built leading sometimes up to 30 miles out from the pump at the river bank and is used for stock watering. In several cases, the pump and channel have been provided primarily for stock watering purposes and any irrigation subsequently developed is subsidiary. This must be taken into account in any economic appraisal of the enterprise.

The economics of integrated part-farm irrigation in this area cannot be dealt with effectively at the present time. Little accurate information regarding costs, watering rates, stocking rates and returns are available at present, and there are still agronomic problems to be resolved.

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