RAINFALL VARIABILITY AND SUPPLEMENTARY IRRIGATION IN COASTAL NEW SOUTH WALES[1]

by

JOHN RUTHERFORD,

Assistant Economics Research Officer.

A more widespread use of supplementary irrigation on farms in coastal[2] areas is destined to play an important part in the future expansion of agricultural output in New South Wales. Flood irrigation from large rivers has changed the landscape in parts of the semi-arid zone of the State, particularly along the Murray and Murrumbidgee rivers. Here closely settled livestock and crop farming areas have developed from sparsely settled grazing land, as an assured soil moisture was provided to farms. It can be expected that future development of irrigation in coastal areas will be of major importance, but it will be less spectacular in scale than that which has taken place in the inland districts. Its role will be to assist improved efficiency of farm production rather than radically change the type of land-use undertaken.

Considerable interest has developed in recent years in the possibilities of greatly extending the use farmers make of irrigation along the coast. Most of this region experiences heavy annual rainfall—sufficient at least to ensure some measure of success for the comparatively intensive crop and livestock industries which are characteristic of the area. For most coastal farmers an important climatic hazard is the variability and seasonal incidence of rainfall. Good seasons are interspersed frequently

[1] Much of the information contained in this article was used in the preparation of a report submitted by the New South Wales Department of Agriculture to the Irrigation Development and Food Production Advisory Committee, and has been incorporated in the Report of this Committee, Part III, "Development of Irrigation in Coastal Districts." (As yet unpublished.) It is desired to thank the Committee for providing some of the material presented in this article.

The author wishes to thank those officers of the New South Wales Department of Agriculture who supplied some of the factual information presented in this article. In particular it is desired to acknowledge the assistance given by district agronomists in coastal areas who supplied the information on the regional availability of irrigable land and the present stage of irrigation development.

[2] For the purposes of this article coastal New South Wales is defined as that portion of the State which lies between the eastern chain of uplands (the Great Dividing Range) and the Pacific sea-board, excluding the rugged country. The combined areas of the various regions depicted on Map I provide a suitable demarcation of the coastal zone.

by dry conditions and at longer intervals by drought. This feature of coastal climate imposes limitations on the overall success which farmers can achieve under natural conditions alone.

Supplementary spray irrigation has been employed already by a small minority of coastal farmers, especially in parts of the Hunter and Hawkesbury valleys. Experience gained on these farms provides ample evidence of the beneficial effects of using irrigation wherever practicable as a means of stabilizing and, in some cases, increasing the growth of crops and pastures.

Some aspects of coastal irrigation development have been discussed in previous issues of this journal [3]. These discussions were concerned mainly with examining the effects of proposed improvements to the supply of water for irrigation and stock water purposes in selected districts. As yet little precise information has been collected on the use of irrigation on particular farms and the types and degrees of benefits which individual farmers have experienced. This type of information is needed before any precise forecast can be made of the likely benefits of the more widespread use of irrigation along the coast.

The main purposes of this article are twofold. First, to present information on coastal rainfall variability made available by more recent studies in the field of climatology. This information enables the agricultural impact of rainfall variability to be seen in a better perspective. Second, to summarize in a general fashion developments in coastal irrigation to the present time, and to describe the experiences which some farmers have had in this field. The general agronomic advantages of irrigation will be summarized.

So that those unfamiliar with the coast can appreciate the proper significance of irrigation, it is proposed to describe at the outset some of the general features of the coast and the relevant characteristics of its rural development.

1. CHARACTER OF THE COASTAL ZONE.

For those who view the coastal zone as climatically "safe" the concept of appreciable irrigation usage in this area might appear somewhat absurd. Relative to other parts of the State, the region is watered by numerous streams, many of which are perennial, and most of the area experiences high average annual rainfalls. These factors, coupled with the closely settled character of the area, might not suggest the need for irrigation development of a significant order. Closer inspection of the coastal environment and the character of its rural development, however, reveals strong weaknesses in such an attitude.

---

[3] See: N. R. Wills and W. F. Owen, "Farming in Sub-Humid Areas—A Study of Agricultural and Climatic Conditions on the Lower Nambucca River, Mid-North Coast, New South Wales", *Review of Marketing and Agricultural Economics*, Vol. 15, Nos. 2 and 3 (February and March, 1947).

Alison M. Kingsland and J. Rutherford, "Coastal River Improvement in Relation to Land Utilization in New South Wales—A Study of Agricultural Conditions and Possibilities of Supplementary Irrigation in the Warrell Creek District of the North Coast". Same journal, Vol. 18, No. 2 (New Series), June, 1950.

In terms of the soil moisture conditions required for maximum success on most of its farms, the coastal belt frequently experiences a lack of rainfall with the result that efficient management is greatly handicapped and considerable production losses are suffered. Most of the crop and livestock industries of the coast have critical requirements with regard to the amount and seasonal incidence of rainfall required for the greatest level and continuity of output. The occurrence of short dry spells at times which are critical for plant growth often inhibits production, not only at the time of deficient rainfall but in succeeding periods as well.

Although the terrain and soil conditions vary quite markedly throughout the coastal zone, a large portion is naturally suited to rural industries which can achieve a relatively high output per acre, including dairying and vegetable production. The region has developed into one of the strategic agricultural zones of the Commonwealth, and has become a vital source of foodstuffs for the large populations which reside within its boundaries[4]. It is for this reason that irrigation and other schemes designed to build up coastal production are vital to the national economy.

Rural Industries.

Dairying is the dominant form of land-use in coastal areas, but important subsidiary industries include the production of fodder crops, citrus fruit, bananas and other tropical fruits, vegetables, pigs, beef cattle and poultry.

Table I shows the relative importance of various coastal industries compared with the State as a whole. Only those industries likely to be directly affected by a development of irrigation have been listed.

TABLE I.

Selected Major Rural Industries in New South Wales Coastal Division compared with State Total.

Industry.	Average Number in Coastal Division* 1946-47–1950-51.	Proportion of State Total.
		Per cent.
Cows in registered dairies	877,737	92·3
Pigs	228,247	65.9
	Acres.	
Maize (acreage)	72,296	67·8
All vegetables (acreage)	32,804	40.9
Citrus (acreage)	17,884	56.3
Bananas (acreage)	22,298	100.0

* The figures in this column refer to the coastal statistical division.

Source.—N.S.W. Bureau of Statistics and Economics.

[4] The population of the coastal statistical division and other areas as at 31st December, 1951, were as follows:—

Area.	*Population.*	*Proportion of Commonwealth. Per cent.*
Coastal Division	2,625,320	30.74
New South Wales	3,358,760	39.33
Sydney (metropolitan area) ..	1,610,580	18.86
Commonwealth	8,538,736	100.00

Source.—N.S.W. Bureau of Statistics and Economics.

Most of the State's dairying industry is concentrated along the coast. Throughout that sector extending from Milton in the south to Wauchope in the north, an increasing emphasis has been given to the production of wholemilk for metropolitan consumption. Farmers supplying milk from this area have been encouraged by financial incentives to increase winter production, so that the problem of improving the continuity of stock feed throughout the whole year has assumed great importance in this part of the coastal belt.

Along other parts of the coast, particularly in northern areas, most dairy farms produce cream for local butter factories. Seasonal production, with considerable emphasis on spring-summer output, is most characteristic of these areas. This is one of the main reasons why the bulk of farmers in these areas place a great deal of reliance on seasonal growth of paspalum and native grasses for stock feed during the peak production months of the year.

With the exception of the metropolitan area, most of the pigs raised in coastal areas are bred and fattened on dairy farms in the "cream" zone where skim milk often constitutes the bulk of the feed used. Pig production would undoubtedly share with dairying any marked benefit that irrigation development might produce.

Much of the maize crop on the coast is grown for fodder purposes on dairy farms. Citrus production is confined mainly to the central coast particularly around and north of the metropolitan area, whilst tropical fruits are confined to the northern parts of the coast.

Vegetables are produced as a sideline to other activities on many farms, especially those with fertile soils which are close to the major urban centres. However, much of the vegetable crop comes from specialized market gardens in the "rural-urban fringe" around the city of Sydney.

Post-war years have witnessed declining or static trends in many rural industries along the coast. Since the pre-war period there has been an almost continuous decline in dairy production[5] and the output of fodder crops, particularly maize. Despite a war-time increase in production, recent years have seen fairly marked declines in the number of pigs raised, and in the acreages under all crops taken as a whole and vegetable crops in particular. The citrus and banana industries are among the few which have expanded to any extent during the last decade.

It is sufficient for the purposes of this article to comment that the level of rural production achieved in coastal areas is well below the potential level to be attained with the most efficient use of resources now available to farmers. The problems associated with achieving any marked expansion in production are complex, but the adoption of better stock feeding practices, improvements in the quality of stock and the development of improved pastures and techniques of crop production will inevitably play vital roles in this field. Supplementary irrigation could greatly assist some of these developments on many farms in both the crop and livestock industries.

---

[5] A reversal of this trend seems to have taken place during the current season.

Topography and Irrigable Land.

The nature of the terrain and soil type are vital determinants of the suitability of land for irrigation farming. What is the position with regard to these factors in the coastal belt? Coastal New South Wales is composed largely of a series of river valleys separated by spurs which trend eastwards from the chain of uplands (the Great Dividing Range) towards the coastline. Within these valleys the headwater regions are too rugged to be regarded as part of the coastal zone which includes the middle and lower reaches of the valleys. For all practical purposes the 700 foot contour line defines the western limit of the coastal zone (see Map I). That portion of the region which is topographically suited to irrigation farming is situated, for the most part, directly adjacent to the middle and lower sectors of the main water courses. Irrigable land suited to crop production is found in some areas on the more moderate lower slopes but, for the most part, it is the pockets and strips of alluvial flats immediately adjacent to the stream courses which are best suited to irrigation both for improved pasture and fodder crop production (see Fig. I). It is in this type of country that land is sufficiently slight in grade and the soil adequately fertile and well-drained for irrigation.

Fig. I shows spray irrigation plant in operation on alluvial flats adjacent to a stream course. Development along lines similar to this is possible on hundreds of coastal farms

(Photo. by courtesy of the Water Conservation and Irrigation Commission.)

Land of this type is naturally most abundant in association with the important river systems. For this reason very much more irrigable land is available along the north and central coastal areas where rivers are comparatively more plentiful, than along the south coast. The Richmond, Clarence, Macleay, Hastings, Manning and Hunter valleys possess large quantities of irrigable land. Approximate estimates of

the regional distribution of irrigable land has been made by district agronomists of the New South Wales Department of Agriculture, and these can be summarized as follows[6]:

Richmond-Tweed.—Extensive strips and pockets of irrigable land are available, mainly for spray irrigation, adjacent to the main streams, particularly along the Richmond River between Wiangaree and Coraki. This land occurs mainly as small lots on farms fronting the watercourses —lots of between fifteen and thirty acres—although larger areas are available on some farms around Kyogle on the Upper Richmond River. Tropical fruit and vegetable production using spray irrigation is possible on many of the more moderate slopes not subject to a high degree of erosion risk.

Clarence.—Many miles of river course are flanked by strips of irrigable flats and about 550 square miles of alluvial country could support the development of improved pastures under irrigation. In this region additional areas of moderate slopes away from the flats could support more production of bananas, tomatoes and vegetables under spray irrigation.

Oxley.—Irrigable land is available in this region in a similar fashion to the aforementioned areas. The exact extent of this type of country is not known but it has been estimated that there are some thousands of acres available along the Macleay and Manning rivers in particular.

Hunter.—The Hunter Valley is the most extensive river basin along the coastal belt and possesses large amounts of land ideally suited to irrigation farming (mainly of the spray type). There are known to be over 28,000 acres of suitable land on the river flats of the middle and upper Hunter between Denman and Aberdeen. Additional areas are available in other parts of the valley mainly along the chief tributary water courses, such as the Williams and Paterson rivers. Important quantities of irrigable flats also exist along the Karuah river north of Newcastle.

Sydney.—It has been estimated that there are at least 10,000 acres of irrigable land available along the main streams other than the Hawkesbury-Nepean proper. About 7,500 acres of suitable land are found along the Colo and Macdonald rivers, Wyong Creek, Jilliby Jilliby Creek and other streams tributary to the Hawkesbury. An additional 2,500 acres are found scattered along minor water courses.

Between Wallacia and Windsor on the Nepean River there are extensive river flats suited to irrigation which are used already in many places for the production of vegetable crops under spray irrigation. Some extensive irrigable flats are to be found throughout the Burragorang Valley, but these will be submerged on completion of the Warragamba Dam. The completion of this project may also make supplies of water for irrigation somewhat uncertain between Wallacia and Windsor.

Below Windsor the Hawkesbury is tidal and can be used for irrigation only when adequate fresh water is flowing to permit pumping.

The Colo River, which joins the Hawkesbury below Windsor, has some good irrigable flats along its lower reaches near Portland, which are already fairly well developed. Several narrow flats are also found as far up as Upper Colo.

[6] The various regions mentioned are those shown on Map I.

South Coast.—In this region there are about 6,000 acres of irrigable land occurring as strips and pockets along the main watercourses. Due to the comparative absence of major streams along this part of the coast, however, the extent of irrigable land is relatively limited.

Potential Areas.—Apart from the abovementioned areas, additional amounts of irrigable land would become available if coastal streams were protected from the intrusion of tidal salt water wherever practicable. Much alluvial land fronting the lower sea-board sections of many streams would become available for the production of improved pastures and some fodder crops under irrigation with the building of small dams across the watercourses designed to maintain a flow of fresh water in the stream courses above the dam sites. One such scheme on the north coast was discussed in a previous issue of this journal[7]. This scheme aimed to free about twelve miles of creek course of tidal water, so that the improved stream could be used for stock water purposes and irrigation of "early" vegetable crops on a group of farms.

It is important to note that, for the most part, coastal land suited to irrigation is distributed in a fragmentary fashion—with strips and pockets of suitable country scattered over widely dispersed areas. Most farms possess comparatively small areas of such land although, in many cases, sufficient is available to permit of efficient working under irrigation.

The distributional pattern of irrigable land on the coast must inevitably influence greatly the type of works which can be employed to bring this land into active use under irrigation. In the inland regions the existence of large and compact areas of land suited to flood irrigation has meant that this country could form the basis of extensive irrigation districts using water commanded by large-scale public works. Such

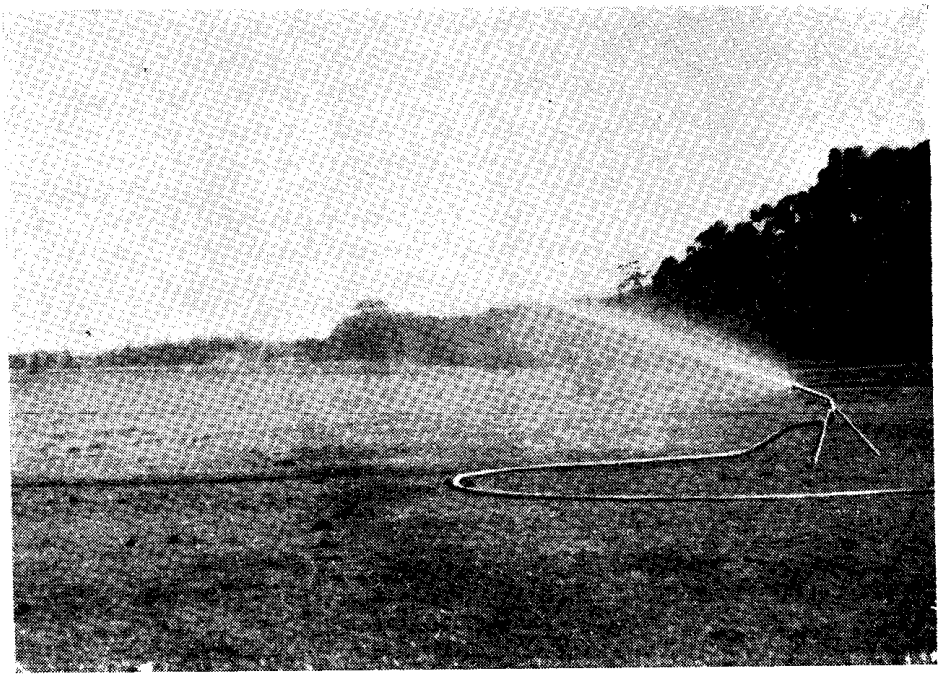


Fig. 11 shows a high pressure "rainmaker" plant in action. This equipment includes a single main nozzle, similar to a fire hose, which is rotated under the action of water, thus distributing water to a circular area of land. In this particular instance the water is being supplied by flexible pipes but permanent pipes can also be employed.

(Photo. by courtesy of the Water Conservation and Irrigation Commission.)

[7] See Alison M. Kingsland and J. Rutherford, *op. cit.*

developments have not only been practical from the physical point of view, but have proved to be comparatively economic investments. For the most part the situation is different in the coastal zone. It would seem that small-scale schemes undertaken by single farmers alone or by groups of farmers will form the most suitable basis for future development of irrigation in these areas, with the possible exception of parts of the Hunter Valley. It is along such lines that development to the present stage has taken place. This point can be illustrated by the following remarks of the Irrigation Development and Food Production Advisory Committee:—

> In the inland areas the costs can be justified by the reticulation of the water in open channels over huge areas of land which can be developed in compact irrigation settlements, supplying not one, two, three or four farms, but hundreds and even thousands of farms. In the coastal belt the terrain generally would necessitate reticulation by pipe line from comparatively remote storages. This combined with the patchy disposition of suitable land would result in very high water costs. This is illustrated by the Water Conservation and Irrigation Commission's investigation of various proposals for community irrigation from major storages. In two such schemes the water charges necessary to recover operating costs and interest on capital would, at the moment, be about £30 and £57 per acre-foot respectively. In inland community irrigation schemes where water is similarly reticulated by gravitation but in open channels existing water charges are less than £1 per acre-foot—although admittedly in some inland projects charges are not high enough to meet interest on capital cost. . . . This Committee is of the opinion that the principle of constructing major headworks in coastal valleys, other than the Hunter, cannot be finally determined without much more information and evidence than is available to-day. It is of the opinion that for years to come the needs of the coast would be met by vastly increasing the spread of individual farm water supply schemes coupled with small communities or groups of farmers operating water supplies made available on a collective basis. Such course of action should be followed vigorously and at once.[8]

Rainfall Characteristics.

Compared with other sections of the State, the coast experiences fairly copious rainfalls *on the average*. The average annual rainfall varies from more than sixty inches on the Far North Coast to about thirty inches on the Far South Coast.

A fairly marked decline in average rainfall occurs with increasing distance from the sea-board[9]. This is illustrated on Map I and it will be seen that the trend is most marked in the Hunter Valley and to the south-west of Sydney. Rainfalls of less than twenty inches per year are frequently experienced in the extreme Upper Hunter region and in the south-western extremities of the Cumberland Plain near Sydney. In the latter case, this trend is accentuated by "rain shadow" effects due to the area being sheltered from rains from the south-west by the nearby uplands.

A marked summer concentration of rainfall is experienced on the average in the northern and far northern sectors of the coast, the accent on rainfall in the warmer months increasing in a northerly direction. This tends to restrict major agricultural production to the warmer months in these areas. On the central coast, and particularly on the south coast, the pattern of seasonal rainfall is more evenly distributed on the average. These areas are therefore more suited than northern districts to all-year-round agricultural production under natural conditions.

[8] *Report of the Irrigation Development and Food Production Advisory Committee, op. cit.*, pp. 13-14 and pp. 23-24.

[9] This trend is reversed once the approaches to the uplands are reached.

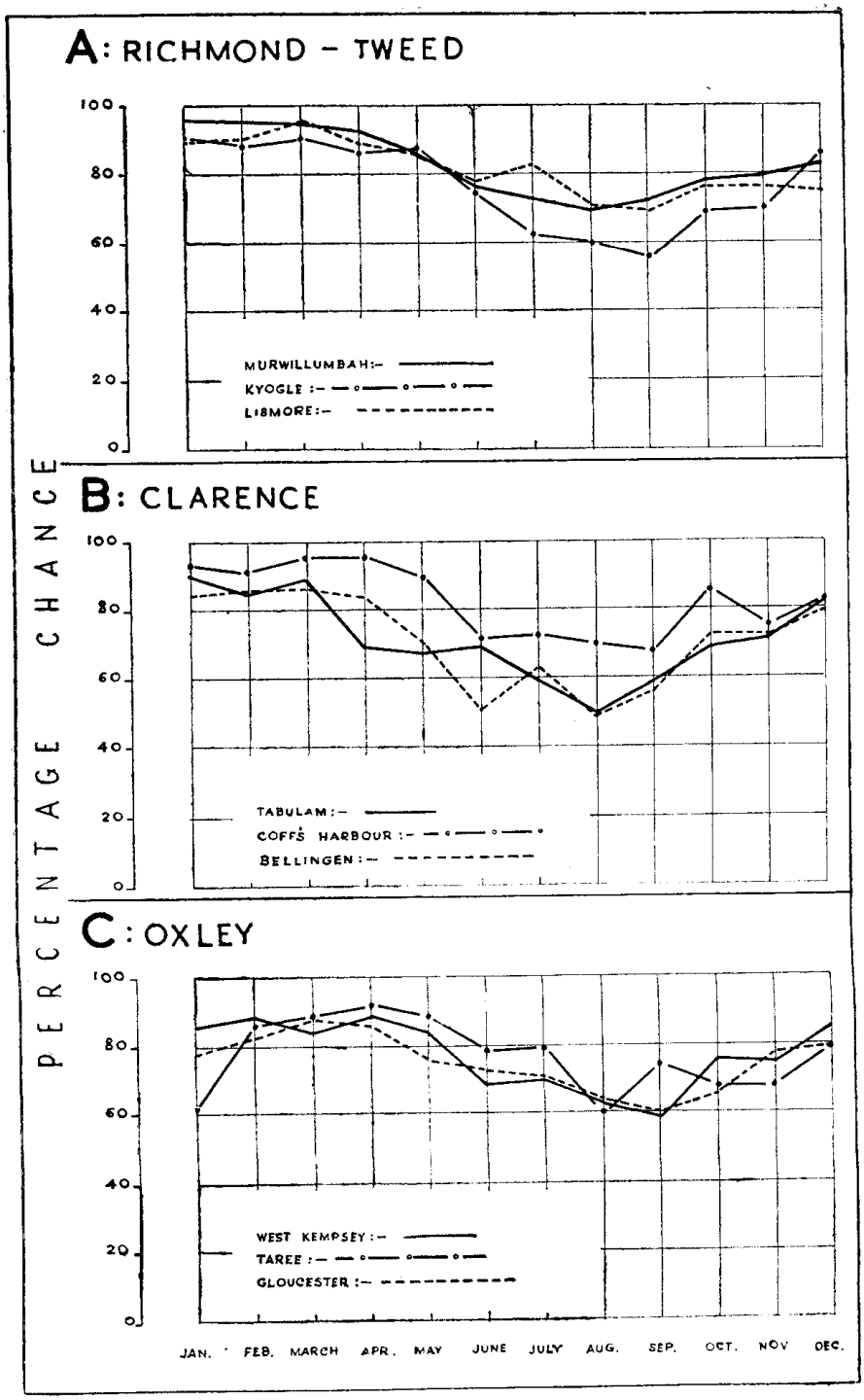


Fig. III. Graphs showing the percentage chance of receiving "effective" rainfalls at selected localities along the coast of New South Wales. (See Table I—Appendix.)

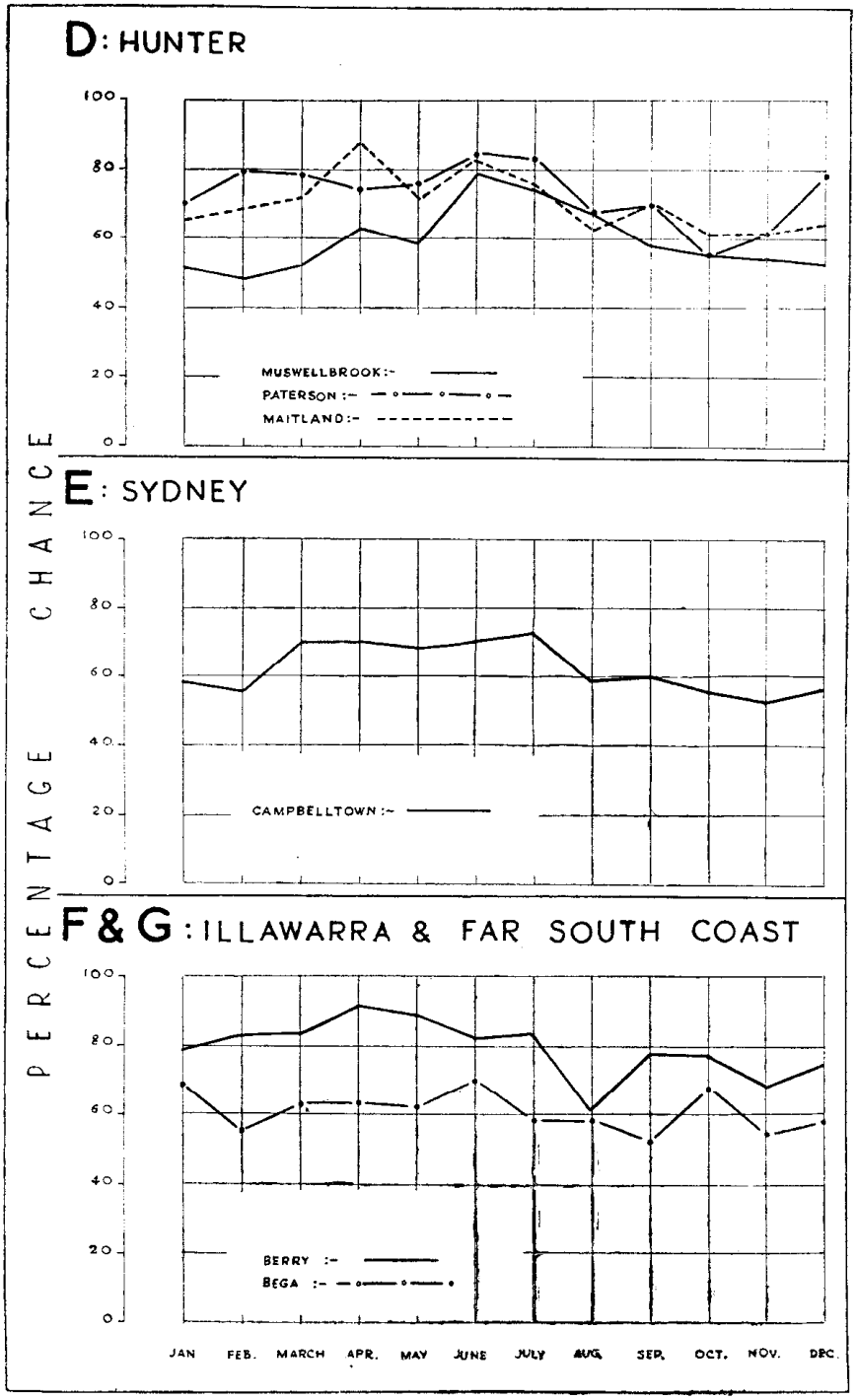


Fig. 111. Graphs showing the percentage chance of receiving "effective" rainfalls at selected localities along the coast of New South Wales. (See Table I—Appendix.)

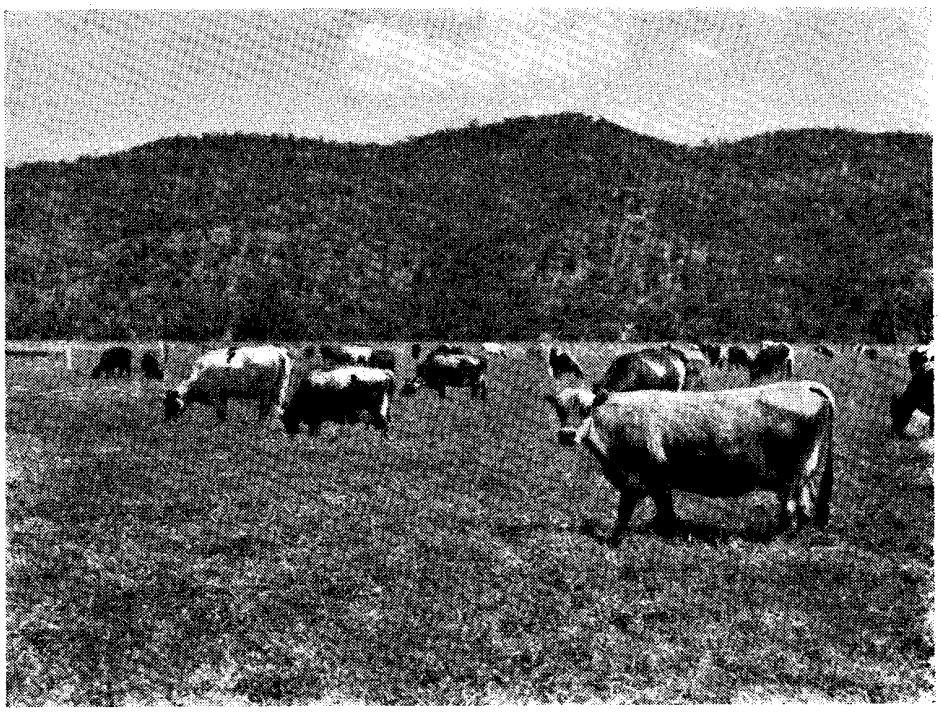


Fig. IV. View of a dairy herd grazing on improved pasture developed on alluvial river flats under spray irrigation.

It should be noted that the seasonal rainfall patterns depicted for selected coastal stations in Table IV (Appendix) and on Map I are average figures based on long-period observations. Any particular year for one of these stations could vary quite markedly from the pattern depicted. Hence, even on the central and south coast, in any one year rains might come at a time which is unusual in terms of average past experience. For example, on the average the Sydney district has a fairly even monthly rainfall distribution. However, for selected stations in the western sector of this region, experience shows that several heavy falls usually occur throughout the year, but these might come at almost any time[10]. This factor of rainfall unreliability is undoubtedly one of crucial importance for agricultural production in coastal areas, and it forms the key to the whole question of irrigation usage in these areas.

How unreliable is the rainfall along the coast and how does this affect the chances of success in farming? With figures now available from recent climatological studies it is possible to provide an answer to this question in a manner which has some practical significance. In terms of conditions needed to maintain plant growth—crops or pastures—and of course the dependent stock, coastal rainfall is far from reliable.

[10] Rain is likely any time during the year on the central and south coast because these areas receive their rainfall from storm movements of both summer and winter incidence. By contrast, northern areas along the coast rely very much more on summer monsoons and invariably have a comparatively dry winter period, being too far distant to share equally with the south coast in winter storm effects.

Most areas experience rainfalls below requirement with an erratic frequency. This factor is well illustrated by the figures contained in Table V (Appendix) and in a clearer form by the graphs of Fig. III. The percentage chance of receiving rainfalls of stated amounts for each month is shown for selected coastal stations. In addition, the calculated "effective" rainfall is shown for each month along with the chance of it being received. The figures for "effective" rainfall have been derived by taking into account (*a*) the needs of plant growth, (*b*) the amount of rainfall likely to be received and (*c*) the losses of rainfall through evaporation [11].

It will be seen that, with the exception of parts of the central and south coast, the greatest reliability is associated with months with greatest average rainfall, *i.e.*, the summer and autumn months (compare Tables IV andV). A very important feature of the north and central coastal areas, where the cream of the agricultural production takes place (dairying, vegetables, citrus and tropical fruits), is the *marked unreliability of the late winter, spring and early summer months* [12].

Most areas along the coast experience late winter and spring rainfalls below the "effective" amounts one year in three to four if close to the sea-board, and as frequently as one year in two in more western areas. The Upper Hunter Valley comes into the latter category, although it will be seen from Fig. III that most months in this area are very unreliable.

These seasonal variations in rainfall reliability can be illustrated by taking several stations as examples: the chance of NOT receiving "effective" rainfalls in December is of the order of twenty per cent. at Murwillumbah (one year in five); ten per cent. (one year in ten) at Casino and slightly less frequently at Kyogle; fifty per cent. at Muswellbrook and slightly less frequently at Campbelltown and Bega further south. In other months, for most of these localities the picture is different. For instance, in the month of August less than "effective" rainfalls are likely to be received in thirty per cent. of years at Murwillumbah; forty per cent. at Casino and Kyogle; thirty-three per cent. at Muswellbrook and slightly more than forty per cent. at Campbelltown and Bega.

The factor of unreliable spring and early summer rains has very important implications for coastal agricultural production. It greatly inhibits maximum development of dairying and many of the other crop industries under natural sub-tropical conditions. On the north coast, for example, where much of the dairying industry is concentrated, most of the production commences in the spring and early summer months and continues on into the late summer. Assured stock feed, particularly

[11] The climatic data have been obtained from the Commonwealth Meteorological Bureau. The rainfall is defined as "effective" if $P/E^{0.7}$ is equal to or greater than the value of 0.54 where P equals the recorded rainfall in inches and E equals the recorded evaporation in inches. The effective rainfall is that required to start germination and maintain growth of plants, including pasture. See C. E. Hounam, "Climate of the West Australain Wheat Belt with Special Reference to Rainfall over Marginal Areas", *Western Australian Pamphlet* No. 1 (1947), Commonwealth Meteorological Bureau.

[12] For the purposes of this article the divisions for the various seasons are taken as follows: *Summer*—December, January and February; *Autumn*—March, April and May; *Winter*—June, July and August; *Spring*—September, October and November.

from pastures, is needed during the spring period to assist in the maximum development of production. The chances of this feed not being available during the critical production months, with serious setbacks, are very high in many districts. Measures such as supplementary irrigation of improved pastures coupled with overall pasture improvement, and better feeding practices to ensure continuity of production, are vital to the stability of the dairying industry.

It should be noted that, as far as successful dairying is concerned, the unreliability of rainfall is probably much more marked than indicated by Table V. In all months of the year, rainfall of a higher order than the "effective" amounts quoted are necessary in most areas to encourage the type of pasture growth necessary for efficient dairying. The "effective" amounts quoted are those calculated to maintain plant growth above the wilting point, whereas successful dairying requires lush growth which would come only from higher rainfalls. As will be seen from Table V the chances of receiving these higher rains is even less than that of receiving the "effective" rainfalls. Very few years have passed when no shortages of rain were experienced at all on the coast.

2. PRESENT STAGE OF DEVELOPMENT OF COASTAL IRRIGATION.

It is difficult to estimate the number of farms which employ supplementary irrigation throughout coastal areas. However, some indication can be gained from the number of licences let to farmers by the Water Conservation and Irrigation Commission for pumping from sources requiring licences. The number of such licences let up to March, 1952, is summarized in Table II, and the regional location of the properties for which these licences apply is shown in Map II (Appendix). A cross-section of the types of land-uses for which irrigation was to be employed by the licences is summarized in Table III[13]. The following points emerge from an examination of this information:—

(i) There is a marked concentration of licences in the Hunter and Hawkesbury Valleys.

(ii) There is a comparative scarcity of licences throughout other parts of the coastal zone, including areas with much irrigable land.

(iii) There are regional differences in the types of land-uses to which irrigation was to be applied. Irrigation of lucerne and fodder crops were the most important uses in most areas except the Clarence and Sydney regions, where vegetable production was an important use. Irrigation of vegetables was also important among the licensees in the Hunter region.

The above information on official licences does not provide the complete picture of the number of coastal irrigationists although it is the only statistical statement available Particularly along the

[13] This information on irrigation licences has been taken from the Report of the Irrigation and Food Production Advisory Committee, *op. cit.*

TABLE II.

Summary of Number of Licences for Irrigation and Farm Water Supply in Coastal Catchments.

(*As at 25th March*, 1952.)

Region.		Total Number of Licences.	Irrigation.		Water Supply.
			Number of Licences.	Area.	Number of Licences.
				acres.	
Richmond–Tweed.	Tweed Catchment	28	28	193	...
	Richmond Catchment ...	65	55	725	10
	Others	29	28	176	1
		122	111	1,094	11
Clarence ...	Clarence Catchment ...	83	50	499	33
	Boambee Catchment ...	32	32	193	...
	Deep Creek Catchment ...	44	44	237	...
	Nambucca Catchment ...	91	84	563	7
	Others	60	59	395	1
		310	269	1,887	41
Oxley ...	Macleay Catchment ...	27	20	266	7
	Manning Catchment ...	55	50	640	5
	Others	25	18	156	7
		107	88	1,062	19
Hunter ...	Hunter River	361	360	8,499	1
	Glennies Creek	28	27	365	1
	Peterson River	72	72	930	...
	Williams River	41	40	504	1
	Other streams	214	206	2,547	8
		716	705	12,845	11
Sydney ...	Hawkesbury River (including Wollondilly and Nepean).	241	227	4,934	14
	South Creek	29	26	512	3
	Others	586	533	6,531	53
		856	786	11,986	70
Illawarra ...	Shoalhaven Catchment ...	59	45	830	14
	Others	20	14	149	6
		79	59	979	20
Far South Coast.	All catchments	30	17	457	13
Total	... ...	2,210	2,035	30,310	185

Source.—Report of the Irrigation Development and Food Production Advisory Committee, *op. cit.*

TABLE III.

*Summary of Crops and Pastures Grown on Principal Streams under Irrigation Licences.**

(As at 25th March, 1952.)

Region.		Crop and Pasture Acreages.†				
		Vegetables.	Fruit.	Lucerne.	Fodder Crops.	Improved Pasture.
Richmond–Tweed.	Tweed	30	...	...	...	...
	Richmond	...	...	167	...	137
	Others	...	...	...	...	...
Clarence ...	Clarence	13	20	68	20	28
	Boambee	127	...	...	...	...
	Deep Creek	151	5	...	...	...
	Nambucca	12	...	47	25	45
	Others	143	27	...	...	...
Oxley ...	Macleay	5	...	50	23	...
	Manning	41	...	38	40	45
	Others	...	...	10	5	...
Hunter ...	Hunter (1)	42	...	374	249	56
	Allyn (3)	27	...	60	35	...
	Glennies Brook (2) ...	4	...	88	10	...
	Peterson (1) ...	32	2	43	15	...
	Williams (2) ...	5	...	96	20	10
	Wollombi (3) ...	38	19	55	65	...
	Wallis Creek (3) ...	36	...	77	15	...
	Others	21	2	336	120	10
Sydney ...	Hawkesbury (1) (including Wollondilly and Nepean).	141	144	157	37	20
	Mooney Mooney Creek (3).	18	192	...	...	...
	South Creek (3) ...	76	...	130	120	...
	Georges (3)	35	35	...	...	2
	Others	699	501	77	144	22
Illawarra and Far Sth. Coast	Shoalhaven (4) ...	82	...	75	20	...
	Others	165	...	317	57	71

* The crop acreages relate to information supplied by licensees when applying for licences.

† In some cases the acreages shown cover only a proportion of the total licences in each river area and the figures represent a sample survey only. In such cases the proportionate representation is as follows :—

(1) One in ten.
(2) One in four.
(3) One in two.
(4) One in six.

Source.—Report of the Irrigation Development and Food Production Advisory Committee, *op. cit.*

middle Hunter River, many farmers irrigate from sources not requiring licences, especially from water bearing sands and gravels which are plentiful in parts of this area. This applies particularly to drought and immediate post-drought periods.

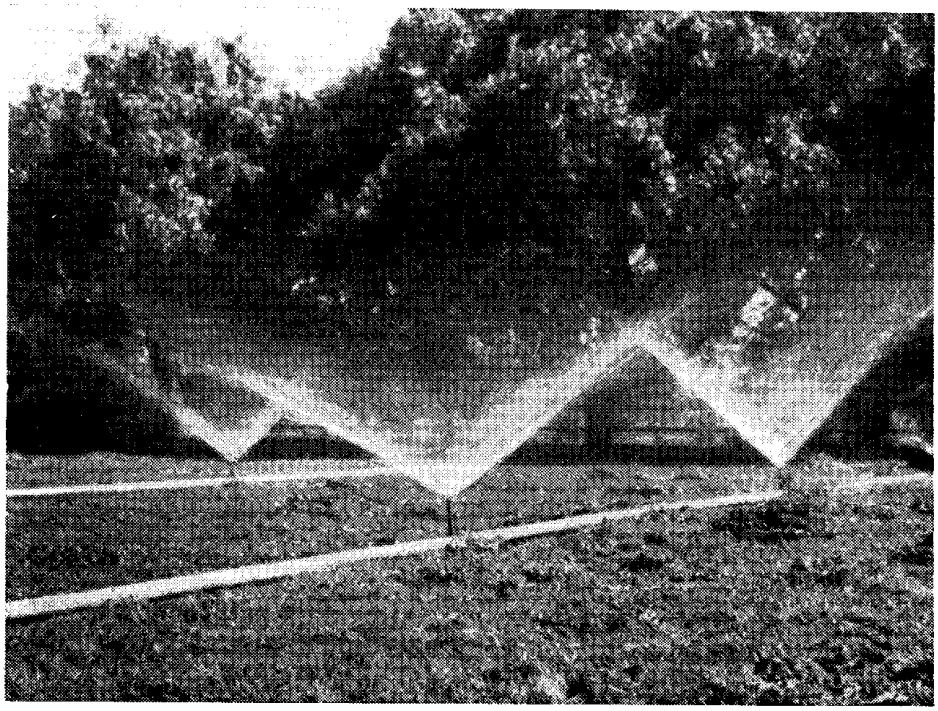


Fig. V shows a portable spray system in operation on improved pastures. The spray lines are attached to a main (not visible) and are placed at the required intervals over the pasture to ensure even watering from fixed nozzles which eject a circular spray.

Compared with the potential number of farms which could employ irrigation with benefit, the present number of irrigationists is small.

The following is a summary of the current position with regard to the use made by farmers of irrigation as reported by officers of the New South Wales Department of Agriculture familiar with the local situation:—

Richmond-Tweed: 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.

Clarence: The number of farmers using irrigation in this region is small and mostly comprises a group of small crop producers with about 300 plants in regular operation. About fifty dairy farmers employ spray irrigation in dry times on small areas of improved pastures and fodder crops, whilst about ten potato growers regularly use spray plants.

Oxley: A fairly large number of plants are used in this region but these are employed on the majority of farms only in times of drought, except by some vegetable growers and in a limited way by farmers regularly irrigating lucerne patches. Most plants are found along the Manning River and tributaries. Between Wingham and Bundook

forty farmers employ irrigation to some extent. In the upper Manning Valley, irrigation is also popular mainly throughout the Gloucester district. Here about thirty dairy farmers employ irrigation mainly for drought relief purposes.

Hunter: Many farmers use irrigation throughout the Hunter Valley chiefly because of the comparatively dry and erratic climatic conditions peculiar to much of this region. In the Dungog Butter Factory district there are known to be forty farmers irrigating some 500 acres. Along the Upper Hunter, above Maitland, and along the Paterson, irrigation plays an increasingly important part in dairying. Near Maitland many farmers employ irrigation for vegetable and lucerne production.

Sydney: The majority of vegetable growers throughout the Cumberland area employ spray irrigation, but in the region north of Sydney only a small portion of the potentially irrigable land is watered at present. Adjoining the water courses, supplementary irrigation plays an increasingly important part in fruit and vegetable production with a limited use for the production of fodder crops on dairy farms.

Compared with pome and stone fruits, irrigation of citrus crops is not practised to any extent. On all fruit crops small portable spray plants are used. The hilly terrain and lack of adequate quantities of water are the main reasons why many citrus growers do not irrigate in the Hills district of the Sydney region. However, the number of fruit farmers employing irrigation is increasing and considerable benefits in the form of stabilized and increased output have accrued to those farmers who make this a practice.

In recent years citrus farmers who have not employed irrigation have found it increasingly difficult to carry on in the face of strong competition from irrigationists. As a result of the droughts of recent years, farmers not practising irrigation have been faced with total crop failures and long range setbacks, whereas a light crop and retained vigour in tree growth have been achieved on those farms employing irrigation.

Vegetable production on the market gardens around Sydney is characterized by very intensive methods, i.e., small farms with a heavy capitalization per acre and a high per acre output. These developments have been made possible to a large extent by the production assurances afforded by irrigation.

Illawarra and Far South Coast: Irrigation is not practised to any extent throughout these regions. On the Far South Coast there are approximately thirty spray plants in operation on dairy farms for pasture development, but these are licensed to irrigate small areas in most instances. In the Illawarra district, approximately fifteen plants have been operated in recent years on small areas of pastures.

On the South Coast irrigation plants are usually employed only in very dry times so that the full advantages are not obtained. There is no particular part of the area where irrigation has played a dominant part in dairying production. It has been of assistance to individuals, but these constitute isolated cases only.

3. AGRICULTURAL BENEFITS OF SUPPLEMENTARY IRRIGATION IN COASTAL DISTRICTS.

General.

The variable character of rainfall in coastal New South Wales—in particular the incidence of insufficient rainfall at critical periods, including the spring months—greatly handicaps the development of more efficient farming methods under natural conditions. This applies particularly to the grazing industries (mainly dairying) which rely heavily on feed from seasonal pasture growth.

The agronomic repercussions of frequent dry spells (especially in spring) may be summarized as follows:—

(i) Failure of, or reduced yields from crops.

(ii) Failure of the more nutritious pasture plants (including the leguminous species) to persist with the result that pastures are dominated by the hardier, but less nutritious plants including Carpet, Parramatta and Blady grasses.

(iii) As a consequence of (i) and (ii) many farmers operating under natural rainfall conditions, particularly on the Far North Coast, are disinclined to adopt a progressive policy of pasture improvement and rotational cropping because of the high costs and risks involved.

It is well known that for a minority of coastal farmers, the use of irrigation during dry spells has played a valuable role in supplementing rainfall and thereby helping to stabilize production of dairy, vegetable and fruit products. Although some increases in output have resulted from irrigation on some farms (especially vegetable production), *stability* rather than increase has been the chief benefit. In the longer-run, of course, stability inevitably leads to higher output and lower costs of production.

Fig. VI. Spray irrigation plant in operation between citrus trees on the coast of N.S.W.

Vegetable crops which form an important element of the primary output from coastal areas are particularly susceptible to failure or greatly reduced yields as a result of insufficient rainfall. This applies both to the total rainfall received through the growing season as well as to the amount received during critical stages of plant growth. Vegetable production without irrigation is hardly an economic proposition in coastal districts.

A survey mentioned previously[14] established that tomato yields in one section of the coast could be increased on the average by 150 per cent. with the use of spray irrigation.

During the 1951-52 drought season, one farmer at Ulmarra on the north coast obtained yields of potatoes of over six tons per acre from irrigated areas at a time when non-irrigationists had crop failures or achieved yields of less than two tons per acre. It has been estimated that irrigation of potatoes can increase yields to an estimated average of 100 per cent. in many coastal areas where suitable water can be obtained and provided efficient farming methods are adopted.

Vegetable producers in locations along the coast suited to "early" crops can benefit greatly from improved farm water supplies and irrigation to ensure maximum yields at times of the year when prices are relatively high. Irrigation has also enabled profitable vegetable production to be undertaken on second-class land in the Cumberland region near Sydney.

The use of irrigation in the citrus and tropical fruit industries of the coast is still in an infant stage. However, experience on some farms has demonstrated that even in hilly areas where due precautions are taken against soil erosion, very marked benefits are derived from irrigation. These benefits accrue from a stabilized output during dry spells, continued vigour of tree growth and, in some cases, considerable increases in yields.

Results achieved on the Duranbah Demonstration Plot (near Murwillumbah in the Far North Coast) have shown that with good management and spray irrigation an average of over 400 bunches of bananas can be obtained economically in a district in which many other farmers average eighty bunches without irrigation and with inferior management practices.

Notwithstanding the benefits to the farmer and the community alike of an enhanced total production through the use of irrigation in the tropical fruit and vegetable industries, the problems which might arise in marketing this enhanced output at a profit to the farmer cannot be overlooked. Where marketing problems are of such a nature that they preclude marked expansion of total output, then the chief benefit of irrigation would be to greatly enhance yields per acre and per unit of labour. Such a development could enable land, labour, and other farm resources to be devoted to alternative forms of production.

The benefits of irrigation to the average coastal dairy farmer would be significant even if less spectacular in most years than those accruing to the producer of vegetables. Where irrigation has been employed already on dairy farms it is exceedingly difficult to isolate the benefits of this single aspect of farm management. The chief role of irrigation is to assist improved management generally.

[14] See Alison M. Kingsland and J. Rutherford, *op. cit.* pp. 125-138.

Supplementary irrigation assists the attainment of the highest level of production at all times and provides an assurance of returns for time, labour and money expended. It should not be regarded solely as an emergency provision against drought.

Assured soil moisture provides greater flexibility to farm management by removing the dependency of production on particular seasonal conditions.

Psychologically, irrigation is beneficial in that it removes a large part of the risk element in farming under natural conditions and encourages a level of capital expenditure that many farmers regard as unwarranted under the uncertainty of natural conditions.

At the present time very many farmers do not regard supplementary irrigation as an *integral part of improved farming at all times.* Many farmers look upon irrigation merely as a stop-gap measure in times of drought. This means that plant lies idle for much of the time and the continuous benefits of irrigation are not derived and returns from capital outlay are thereby greatly reduced.

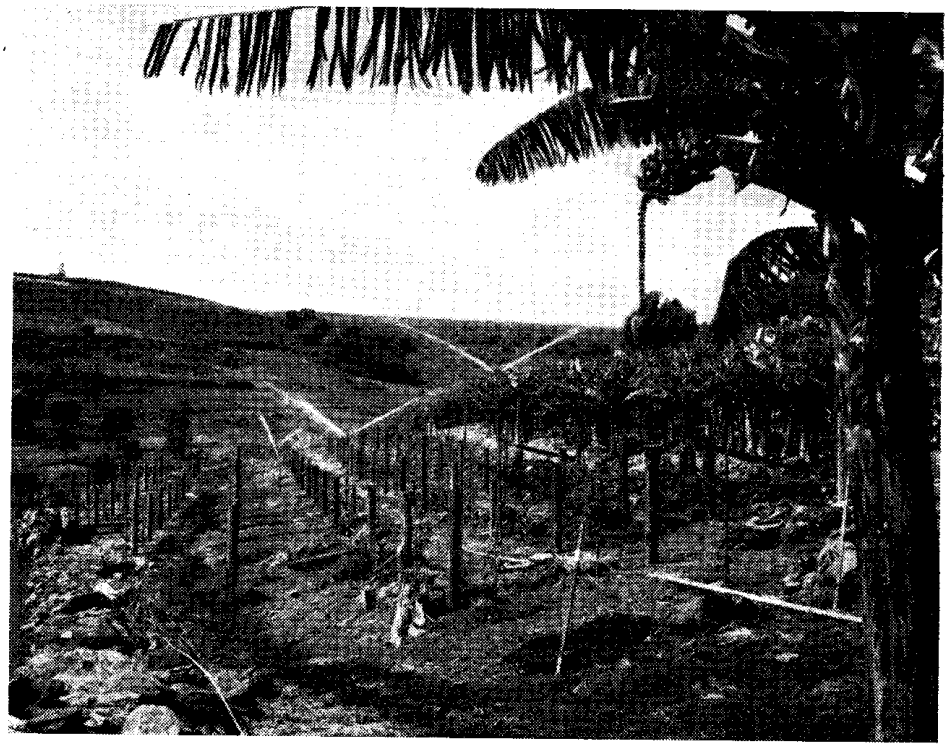


Fig. VII. Irrigation of passion fruit (in banana plantation) on sloping land at the Duranbah Demonstration Plot on the Far North Coast of New South Wales.

Officers of the Department of Agriculture have reported that one of the chief reasons why many farmers are loth to invest in irrigation plants is the relatively large initial capital outlay involved. These farmers look with disfavour on the spending of as much as £1,000 for irrigation plant which they expect to employ only sporadically—perhaps two years in five. Where supplementary irrigation is used only as a bridge during droughts, such an attitude is perhaps justified.

However, an examination of certain farms which employ irrigation of pastures leaves no doubt that small-scale irrigation wherever practicable can greatly benefit the average dairy farmer when allied with efficient management of improved pastures. Irrigation will pay most when it is used regularly rather than sporadically.

Examples of Dairy Farms with Irrigation.

It is proposed to illustrate the manner in which supplementary irrigation of pastures can assist more efficient dairy production by reference to three properties, each of which is representative of important groups of farms in coastal areas.

Case I.—This farm is situated on the alluvial lowlands of the Richmond River in the vicinity of Kyogle [15]. It comprises 226 acres, 100 of which are well-drained alluvial flats, the balance being undulating to hilly land. It carries 150 head of dairy stock of the Jersey-Guernsey breed, which rely for their feed on improved pastures alone. Three adult males comprise the permanent labour force on the farm.

TABLE IV.

Changes on a North Coast Dairy Farm which Employs Supplementary Irrigation of Improved Pastures.

Year.	1943–44.	1944–45.	1945–46.	1946–47.	1947–48.	1948–49.	1949–50.	1950–51.	1951–52.
Number of cows	90	90	75	75	80	85	100	100	100
Area in acres	290	290	226	226	226	226	226	226	226
Total production in commerical butter	lb. 15,201	lb. 17,644	lb. 14,098	lb. 12,981	lb. 21,727	lb. 22,779	lb. 28,484	lb. 28,629	lb. 22,230
Average commercial butter per cow	169	196	189	173	272	268	284	286	222
Commercial butter per acre	52	61	62	57	96	101	126	127	98

Adapted from S. R. Ballard and John Guild, *op. cit.*

Table IV summarizes some of the main developments which have occurred on this farm since the 1943-44 season. Several distinct changes have occurred in this period. First there has been a build-up of herd size despite a decline in farm size. Second, there has been a marked increase in output reflected in marked increases in production per cow and per acre.

These increases in production cannot be attributed to any single aspect of management, but have resulted from the combined effects of the following factors:—

(*a*) Top-dressing of pastures with lime and superphosphate;
(*b*) sowing of improved pastures;
(*c*) close subdivision of pasture land for rotational grazing;
(*d*) spray irrigation of improved pastures to bridge dry spells and droughts;
(*e*) general management.

[15] For a detailed description of this farm see: S. R. Ballard and John Guild, "Increased Dairy Production from Improved Pastures", *The Agricultural Gazette of New South Wales*, Vol. LXIII, Part 5 (May 1, 1952), pp. 232-235.

Fig. VIII shows the comparative absence of clover development under favourable early spring conditions on a Kyogle dairy farm. This view depicts an improved pasture which had not been irrigated during the preceding spring-summer drought.

Fig. IX. View of a pasture on the same farm as depicted in Fig. VIII which shows the marked clover development in a pasture which had been watered during the preceding spring-summer drought. Both views (Fig. VII and Fig. IX) were taken on the same day in early spring, 1952.

The alluvial flat section of the farm is sub-divided into nineteen paddocks which are used in rotation with daily changes of paddocks. This provides a fairly lengthy period for recovery. New Zealand white clover is the dominant legume in the pasture and grows almost the year round. In the spring it dominates the paspalum. A markedly increased spread in the growing period of the white clover has occurred in recent years; a result mainly of general improvements in soil fertility and improved soil moisture conditions induced by spray irrigation in dry times.

Irrigation has not only enabled the clover to persist during dry weather but has permitted a good growth response to light falls of rain in subsequent periods. This is illustrated by a comparison of Figs. VIII and IX. Both these photographs were taken during early August, 1952, following favourable early spring rains. Fig. VIII illustrates a pasture dominated by paspalum with comparatively little clover development. This is typical of an area which had previously been top-dressed along with other areas but which had not been watered during the preceding spring-summer drought. By contrast, Fig. IX illustrates an area that *was* irrigated in this period, and the response of clover to favourable conditions in the subsequent spring is very marked. At the time this photograph was taken the clover was dominating the pasture. As both areas had similar treatment in other respects, the differences in clover development can be attributed to the irrigation factor alone.

The above example serves to illustrate the long-run effects of irrigation on pasture growth. Irrigation not only permits pasture to persist during dry times but makes the pasture more responsive to favourable natural conditions in subsequent periods. It is for this reason that irrigation plays an integral role in successful pasture establishment in areas subject to erratic rainfall.

On this farm, irrigation is applied to as much as 80 acres of land using the following equipment: a 3-inch pump driven by a 20 h.p. diesel motor; 10 chains of 3-inch spray line and 20 chains of 4-inch main line. The water is obtained from the Richmond River. Water is applied for as much as twelve hours per day at the rate of 1 inch per hour, each area being given three inches of water at a time. The spray lines are shifted twice per day, half an acre being covered at a time. In an average short dry spell as much as sixty acres of pasture are covered two to three times in this manner.

Although this property is by no means typical of the majority of coastal dairy farms, it does illustrate the type of development which is possible on those properties which possess fairly large amounts of irrigable land and sufficient labour supply.

The essential advantage of irrigation on this property is that it has enabled a system of grassland farming to be adopted on a reliable basis, the whole production programme being geared around improved pasture management.

Case II.—This farm is located on the alluvial lowlands of the Richmond River near Coraki, some nine miles south of Casino. The total area of the property is 280 acres including eighty acres of well-drained alluvial flat. The balance of the farm is poorly drained except in dry seasons. The farm supports a herd of 112 Jersey stock.

Whilst some pasture improvement has been undertaken at various times over the whole property, the best and most recent developments have occurred on fifteen acres of good alluvial land adjacent to the Richmond River. This area has been irrigated at various times and supports a paspalum-white clover pasture regularly top-dressed with superphosphate and intensively sub-divided for rotational grazing.

The irrigation plant in use includes a 4-inch pump at present driven by a 17 h.p. tractor. Pipes for spray irrigation include twelve chains of 4-inch main line and twelve chains of 4-inch spray line. Supplementary irrigation has been employed only recently on this farm, the first prolonged use being made during the drought of the 1951-52 season. During this period three complete waterings of three inches a time were appled to the fifteen acres of improved pasture. This maintained good pasture growth at a time when very little feed was available from any other source.

Production during the drought was maintained at a satisfactory level although neighbouring farmers were suffering serious losses. The operator of the property has stated that some irrigation is essential on his property in almost every year to maintain continuity of production. He estimated that without assistance from irrigation the average yearly production from the farm would be about seventy per cent. of that achieved with irrigation.

This farm is fairly typical of many coastal dairy farms in that it possesses only small amounts of irrigable land although there is enough to be adequately handled by a limited labour force. Irrigated pasture would not be the sole or main source of feed for extended periods, but would provide a stop-gap source of relatively cheap feed to bridge critical dry spells.

Case III.—A valuable experiment in the development of an improved farm water supply and the irrigation of improved pasture has been undertaken at the McGarvie Smith Animal Husbandry Farm, Badgery's Creek, near Sydney. This is a 400-acre farm which forms part of the Faculty of Veterinary Science of the University of Sydney. A total of forty-five dairy cows are maintained on the farm, most of which are stud Jerseys. The farm produces wholemilk for city distribution, and has a labour force which consists of one farm foreman, two men and two boys.

The farm is made up of undulating country of poor clay soils with a small area of creek flat with podsolised soils. Although fairly close to Sydney, the farm experiences a low average rainfall of about twenty-five inches per annum. The greatest climatic problem on the farm is variability of rainfall rather than a lower overall rainfall. Rains are likely to be received mainly in one or two falls each year, but these might come at almost any time throughout the year. This uncertainty of rainfall is the main reason why farmers in the Cumberland region have found it difficult to successfully establish improved pastures except in favourable seasons.

Fig. X showing portion of a farm dam constructed for the purpose of storing run off during periods of heavy rainfall. Dams such as these can be developed on many coastal farms to serve irrigation plants when other sources of fresh water are not available.

(Photo. by courtesy of the Water Conservation and Irrigation Commission.)

The clay soil and undulating character of the farm have made it very suitable for the development of small dams for catching the bulk of surface run-off on an economic basis. The water from these dams is pumped back by means of spray irrigation on to the land during periods of deficient rainfall.

Current experiments at the farm involve the use of supplementary irrigation on small areas of improved pasture (subterranean clover) to maintain continuity of growth for as long as possible. One such area has recently been strip-grazed at a very high rate of stocking (equivalent to 450 cows per acre), the grazing being followed by spelling and spray irrigation to encourage recovery of the pasture. This kind of management has enabled a high yield of milk to be maintained at a level of costs which is low by comparison with returns achieved.

These experiments in the improvement of farm water supplies and irrigation of improved pastures, although in an early stage, have demonstrated clearly the scope which exists for improving dairy production throughout the coast on hundreds of comparable farms which suffer from erratic rainfall. The building of small dams can enable farmers to store water during times when rains are in excess of current needs for use at other times of the year. Where the topography and soil allow developments along these lines to be undertaken at a relatively low cost, many of the problems of rainfall unreliability can be overcome.

Provision is already 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[16]. Among other things, the Act provides for the giving of technical assistance by Water Conservation authorities, and the granting of financial

[16] For a full explanation of this Act see: "Enough Water," a pamphlet issued under the authority of the Water Conservation and Irrigation Commission of New South Wales.

aid in the form of loans at low rates of interest through the Irrigation Agency of the Rural Bank of New South Wales for farm water supply purposes. The Act covers schemes both on individual farms and groups of farms.

A considerable amount of work has already been undertaken in coastal areas to improve farm water supplies under the provisions of this Act. There is no doubt that the widespread extension of this work to hundreds of additional farms will greatly benefit coastal agricultural production in future years.

In considering the possibility of a marked expansion of irrigation usage throughtout coastal areas, a continuous supply of suitable water in all areas cannot be taken for granted. During very dry seasons shortages of water have occurred already in some parts of the coast and if any significant increase in the demand for water for irrigation purposes took place, serious shortages might arise in some localities at times when irrigation was most needed.

To this extent, the fullest development of irrigation will require concomitant developments of suitable water supplies in areas where natural perennial sources are absent. This will involve the building of small dams and weirs to pond water on farms, and to remove salting due to tidal influences, as well as the development of subterranean water resources.

4. CONCLUSIONS.

This article has dealt with some aspects of the variable character of rainfall throughout the coastal sector of New South Wales, and the scope for increased development of supplementary irrigation in this region. The following points have emerged:—

(i) Despite relatively high annual rainfalls, the coast experiences marked unreliability of rains in critical seasons of the year, especially during the spring and early summer months. This factor alone imposes severe limitations on the success which farmers can achieve under natural conditions.

(ii) There is considerable scope for improvement in farming techniques and levels of production in coastal industries, many of which hold significant places in the list of rural industries of the State of New South Wales.

(iii) Unlike inland areas, where large-scale irrigation areas have developed with the assistance of comprehensive public works, the scope for development of irrigation in coastal areas lies mostly in the adoption of numerous small schemes on individual farms and groups of farms. This results mainly from the scattered and fragmentary nature of irrigable land in coastal areas.

(iv) In terms of climatic conditions, topography and water resources, the coastal zone is well suited to a widespread development of supplementary spray irrigation. A large proportion of holdings could benefit.

(v) Irrigation is still in its infancy on the coast, although some worthwhile development of spray irrigation has occurred in parts of the Hunter and Hawkesbury-Nepean valleys. Producers of vegetables are the main users of irrigation and fairly continuous reliance is placed on plants. By contrast, most of the dairy farmers using irrigation plants employ this equipment irregularly, mainly in drought times, and, as a consequence, benefits are limited.

(vi) Supplementary irrigation, wherever practicable, can be basic to the success of many forms of primary production in coastal areas, and if constantly employed it can form an integral part of a general programme for farm improvement in the dairying industry. This is of great importance in view of the significance of the agricultural output of the coastal region.

The present potential value of supplementary irrigation is to stabilize rather than greatly increase production in the major coastal industries, although marked increases in output can be achieved under irrigation in the small crop and fruit industries.

(vii) The benefits of irrigation and the facilities available to farmers desirous of installing irrigation equipment should be publicized as much as possible.

5. APPENDIX.

TABLE IV.

*Average Monthly and Annual Rainfalls Selected Coastal Stations, N.S.W.**

Region.	Rainfall Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Richmond–Tweed...	Tweed Heads ...	7.57	8.27	9.84	6.82	6.20	4.36	3.78	2.77	2.97	3.55	4.39	5.14	65.66
	Casino	5.49	5.48	5.72	4.04	3.02	2.39	2.42	1.77	1.90	2.76	3.01	4.24	42·84
	Kyogle	6.27	5.20	5.60	4.30	3.42	2.44	2.67	1.46	1.88	2.56	3.48	5.73	45.01
	Lismore	6.26	6.54	7.27	5.06	4.64	3.27	3.45	2.35	2.33	2.63	3.83	4.51	52.14
Clarence	Maclean	5.16	5.08	5.85	4.52	4.21	3.11	3.17	2.07	2.06	2.54	3.56	4.15	45.48
	Clarence Heads ...	5.63	5.32	6.62	5.90	6.22	4.67	4.35	3.18	2.67	2.89	3.35	4.33	55.13
	Grafton	4.87	4.43	4.15	3.25	2.52	2.40	2.07	1.47	1.81	2.42	3.11	3.72	36.22
	Woolgoolga	6.45	7.40	7.72	6.59	5.91	4.35	4.18	3.19	2.94	3.80	3.95	5.34	61.82
Oxley	Kempsey (West) ...	4.81	5.46	5.14	4.37	3.50	3.35	3.11	2.44	2.58	2.97	3.27	4.07	45.07
	Taree	4.60	5.23	4.97	4.84	3.64	3.31	3.53	2.58	2.68	2.76	3.06	4.23	45.43
	Gloucester	4.05	3.89	4.68	3.21	2.50	2.43	2.58	1.96	2.20	2.57	3.24	4.35	37.66
Hunter	Singleton	2.80	2.56	2.97	2.27	1.75	2.06	2.25	1.47	1.85	1.97	2.42	2.94	27.31
	Muswellbrook ...	2.39	2.16	2.20	1.73	1.58	1.92	1.94	1.50	1.66	1.70	2.08	2.43	23.29
	Merriwa	2.53	1.99	2.10	1.59	1.32	1.60	1.71	1.46	1.62	1.54	2.03	2.40	21.89
	Newcastle	3.31	3.83	4.65	4.63	4.77	3.75	4.44	3.08	3.19	2.84	2.54	3.25	44.28
	Maitland	3.17	3.17	3.64	3.15	2.55	2.49	2.67	1.96	2.56	2.26	2.32	3.13	33.07
Sydney	Gosford	3.97	4.44	5.58	5.11	4.90	3.72	4.57	3.12	3.38	2.98	3.12	3.69	48.58
	Sydney	3.54	4.02	4.95	5.26	5.02	4.61	4.59	2.98	2.87	2.83	2.85	2.94	46.46
	Parramatta	3.33	3.32	3.97	3.38	2.98	2.76	3.22	2.10	2.12	2.34	2.41	2.87	34.80
Illawarra	Berry	5.41	4.90	5.98	5.58	5.32	4.86	4.88	3.18	3.37	3.26	3.39	4.74	54.87
	Jervis Bay	3.62	3.12	4.24	4.90	5.28	4.01	4.76	3.39	2.94	2.69	2.60	3.49	44.95
	Milton	4.14	4.29	4.83	5.10	5.14	3.89	4.01	2.49	2.93	3.58	3.43	3.56	47.39
Far South Coast ...	Bodalla	3.93	3.63	3.99	3.01	3.12	2.78	2.41	2.01	2.53	2.74	2.72	2.99	35.86
	Bega	3.56	3.25	3.60	2.56	2.86	3.08	2.25	2.08	2.05	2.50	2.13	3.02	32.94
	Eden	3.57	3.10	3.26	2.93	3.07	3.12	2.33	2.26	2.36	2.64	2.55	2.69	33.88

* Figures obtained from *Results of Rainfall Observations Made in New South Wales. Section I* (1948 Commonwealth Bureau of Meteorology).

TABLE V.

Rainfall Variability at Coastal Localities Expressed in Terms of the Percentage Chance of Receiving Stated Amounts of Rainfall Each Month. *

Region.	Station.	Amount of Rainfall.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		inches.												
Richmond-Tweed...	Murwillumbah ...	1	99	97	97	93	85	75	71	65	77	84	92	91
		2	95	92	91	83	72	62	52	41	57	67	72	81
		3	86	84	85	70	59	51	39	26	38	46	51	68
		4	76	75	77	59	46	41	31	17	25	30	35	57
		E.R.	1.73	1.49	1.49	1.17	0.96	0.90	0.90	0.93	1.20	1.43	1.69	1.82
		% CH.	96	95	94	92	86	76	73	69	72	77	79	83
	Mullumbimby ...	1	96	97	98	93	89	81	72	80	69	81	90	98
		2	89	90	92	85	81	63	56	52	49	62	70	87
		3	80	80	86	76	73	52	44	32	38	47	52	75
		4	71	70	78	68	65	42	35	20	27	35	39	58
		E.R.	1.75	1.49	1.49	1.14	0.96	0.90	0.90	9.03	1.22	1.43	1.67	1.80
		% CH.	93	94	95	91	89	83	74	82	64	73	77	90
	Kyogle	1	95	92	94	88	85	70	58	55	60	80	82	97
		2	89	83	84	76	67	46	41	20	38	53	65	84
		3	81	72	71	61	45	33	30	8	26	35	50	71
		4	72	69	57	49	28	26	22	2	17	21	38	60
		E.R.	1.71	1.47	1.45	1.14	0.90	0.88	0.88	0.90	1.14	1.43	1.69	1.82
		% CH.	91	88	90	86	87	74	62	60	56	68	70	86
	Lismore	1	98	95	97	89	84	75	71	67	78	83	90	93
		2	87	84	90	78	70	58	56	35	50	58	66	80
		3	73	73	78	65	57	47	44	24	28	32	49	61
		4	61	63	67	52	43	37	33	17	13	18	38	44
		E.R.	1.82	1.49	1.49	1.11	0.96	0.90	0.90	0.93	1.17	1.43	1.67	1.80
		% CH.	89	90	95	88	85	77	83	71	69	75	76	74

TABLE V—*continued.*

Rainfall Variability at Coastal Localities Expressed in Terms of the Percentage Chance of Receiving Stated Amounts of Rainfall Each Month *—continued.

Region.	Station.	Amount of Rainfall.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		inches.												
Richmond-Tweed—*contd.*	Casino	1	95	95	94	84	76	67	60	57	65	82	92	96
		2	85	85	84	67	53	49	41	25	41	56	72	85
		3	71	71	73	52	33	32	28	12	22	34	50	61
		4	55	59	60	38	21	23	18	9	9	20	31	42
		E.R.	1.82	1.47	1.45	1.11	0.90	0.88	0.88	0.90	1.14	1.43	1.69	1.82
		% CH.	87	90	90	82	78	70	63	59	62	70	80	88
Clarence	Tabulam	1	98	90	92	74	67	66	55	44	63	80	84	94
		2	88	78	82	51	38	52	33	21	38	54	64	81
		3	75	63	70	35	24	42	22	10	21	31	47	66
		4	55	45	57	23	15	32	14	2	9	17	35	47
		E.R.	1.89	1.54	1.47	1.14	0.99	0.84	0.84	0.88	1.14	1.45	1.67	1.92
		% CH.	90	84	88	69	67	69	59	50	59	69	71	82
	Coff's Harbour ...	1	100	94	96	94	88	69	70	66	70	92	88	96
		2	91	88	92	86	76	56	51	42	50	71	65	75
		3	78	81	85	78	62	46	37	29	30	42	51	66
		4	63	73	79	70	51	38	27	21	17	28	40	54
		E.R.	1.80	1.49	1.49	1.05	0.93	0.90	0.88	0.90	1.17	1.40	1.59	1.82
		% CH.	93	91	94	94	89	71	72	70	67	85	75	82
	Dorrigo	1	100	97	98	97	84	82	72	63	74	88	88	100
		2	99	92	95	92	73	62	57	46	59	76	75	94
		3	95	84	92	87	64	50	44	34	46	61	62	85
		4	88	70	88	78	55	42	35	26	35	45	52	76
		E.R.	1.73	1.45	1.45	0.93	0.81	0.87	0.78	0.84	1.05	1.35	1.61	1.84
		% CH.	100	95	96	97	87	86	76	67	73	84	80	96

TABLE V—*continued.*

Rainfall Variability at Coastal Localities Expressed in Terms of the Percentage Chance of Receiving Stated Amounts of Rainfall Each Month *—continued.

Region.	Station.	Amount of Rainfall.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		inches.												
Clarence—*contd.*	Bellingen	1	90	87	87	84	69	58	61	46	58	80	80	87
		2	82	81	83	74	57	46	47	27	38	56	67	77
		3	73	70	79	63	46	38	37	19	24	36	53	68
		4	62	56	73	54	38	32	30	14	17	27	40	55
		E.R.	1.78	1.47	1.47	0.99	0.90	0.88	0.84	0.88	1.08	1.37	1.59	1.82
		% CH.	84	85	86	84	70	51	63	49	56	72	72	79
	Macksville ...	1	96	90	97	83	76	71	66	59	70	81	86	92
		2	87	79	89	69	60	57	50	37	45	55	63	76
		3	70	65	77	55	44	48	37	24	30	36	43	56
		4	49	56	68	44	34	39	28	17	24	26	30	42
		E.R.	1.82	1.29	1.43	0.96	0.81	0.81	0.84	0.88	1.11	1.32	1.49	1.78
		% CH.	89	88	94	84	79	74	69	62	67	72	77	81
Oxley	West Kempsey ...	1	93	94	92	88	82	66	68	60	60	82	85	93
		2	81	76	77	69	63	48	50	36	39	62	65	82
		3	63	62	63	51	42	37	40	24	24	31	45	62
		4	47	52	52	38	31	29	32	18	18	20	28	39
		E.R.	1.73	1.49	1.49	0.99	0.90	0.88	0.84	0.90	1.05	1.37	1.59	1.82
		% CH.	85	88	84	88	84	68	70	63	58	76	75	85
	Wauchope ...	1	96	91	95	93	79	71	67	55	64	82	83	97
		2	85	75	87	70	62	55	51	30	44	60	60	77
		3	61	58	71	50	48	43	42	24	32	40	43	59
		4	46	45	56	40	36	35	34	20	25	26	32	43
		E.R.	1.86	1.32	1.43	1.02	0.72	0.78	0.81	0.84	1.08	1.29	1.52	1.80
		% CH.	87	87	92	93	85	73	71	60	64	76	71	80

TABLE V—*continued.*

Rainfall Variability at Coastal Localities Expressed in Terms of the Percentage Chance of Receiving Stated Amounts of Rainfall Each Month *—continued.

Region.	Station.	Amount of Rainfall.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		inches.												
Oxley—*contd.*	Taree	1	81	90	94	92	85	73	76	57	74	76	79	95
		2	58	78	78	78	58	53	56	38	49	50	58	73
		3	42	65	57	58	37	42	42	28	29	31	42	55
		4	31	50	46	44	28	33	32	21	22	21	29	41
		E.R.	1.78	1.47	1.47	1.08	0.96	0.88	0.84	0.88	1.05	1.35	1.61	1.80
		% CH.	61	86	89	92	89	79	79	60	74	68	68	79
	Gloucester ...	1	91	88	95	86	69	65	62	59	62	74	85	91
		2	75	70	75	63	41	46	44	35	41	46	69	76
		3	56	50	59	38	26	35	35	21	30	28	46	62
		4	44	26	46	26	19	27	28	12	21	21	31	50
		E.R.	1.94	1.35	1.47	1.05	0.81	0.72	0.72	0.84	1.08	1.35	1.57	1.82
		% CH.	77	83	88	86	57	73	71	64	60	66	77	79
Hunter	Scone	1	87	68	68	66	52	59	62	58	67	72	72	82
		2	59	45	42	31	24	32	32	27	34	37	44	57
		3	32	32	26	19	13	20	18	13	17	12	23	34
		4	18	21	17	10	6	13	9	5	10	4	9	20
		E.R.	2.07	1.71	1.52	0.99	0.84	0.69	0.65	0.81	1.14	1.29	1.75	1.98
		% CH.	57	51	53	66	55	74	77	67	59	60	50	57
	Muswellbrook ...	1	84	63	64	63	50	66	63	58	65	66	73	78
		2	53	42	44	34	27	37	38	25	27	35	47	51
		3	28	38	27	19	16	23	21	11	13	17	23	30
		4	14	19	16	10	7	14	11	4	7	5	8	15
		E.R.	2.07	1.69	1.52	0.99	0.84	0.69	0.65	0.81	1.14	1.27	1.75	1.98
		% CH.	51	48	52	63	55	79	74	67	58	55	54	52
	Denman	1	80	57	59	58	45	53	51	53	58	62	69	81
		2	51	35	40	32	22	30	30	21	28	30	46	45
		3	25	23	25	17	10	17	18	8	14	15	26	28
		4	13	15	14	8	5	9	10	3	6	6	12	17
		E.R.	2.13	1.71	1.54	0.99	0.84	0.69	0.65	0.79	1.14	1.27	1.78	1.98
		% CH.	47	41	48	59	50	67	65	62	50	50	51	45

TABLE V—*continued.*

Rainfall Variability at Coastal Localities Expressed in Terms of the Percentage Chance of Receiving Stated Amounts of Rainfall Each Month *—continued.

Region.	Station.	Amount of Rainfall.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		inches.												
Hunter- *contd.*	Paterson	1	91	83	86	84	72	77	78	65	70	63	72	90
		2	69	68	68	67	46	51	58	32	51	41	54	75
		3	53	51	57	44	28	38	42	17	38	26	39	59
		4	41	35	47	29	21	31	31	9	29	17	26	44
		E.R.	1.94	1.35	1.37	1.05	0.90	0.72	0.72	0.93	1.02	1.35	1.50	1.80
		% CH.	70	79	78	74	75	84	83	67	70	55	61	78
	Singleton	1	81	70	74	71	52	70	66	60	69	71	76	82
		2	62	46	51	63	28	38	43	30	34	41	55	60
		3	41	32	37	24	17	25	27	10	19	22	34	40
		4	21	23	26	15	11	15	15	4	10	8	13	23
		E.R.	2.07	1.61	1.61	1.11	0.90	0.75	0.69	0.84	1.08	1.43	1.78	1.96
		% CH.	61	54	59	67	57	78	77	67	66	64	60	62
	Dungog	1	87	82	88	84	75	71	75	57	69	70	78	96
		2	67	65	67	64	51	46	55	37	46	43	55	77
		3	50	51	50	49	29	33	41	22	32	29	36	57
		4	36	36	38	35	16	26	29	13	24	20	24	40
		E.R.	2.00	1.52	1.52	1.08	0.93	0.78	0.75	0.88	1.05	1.37	1.69	1.96
		% CH.	67	76	80	84	79	81	80	60	68	56	61	80
	Maitland	1	86	77	82	87	70	72	68	56	71	71	80	83
		2	64	59	60	60	43	44	50	30	48	40	53	61
		3	42	42	44	30	30	31	36	17	34	20	26	39
		4	28	39	32	20	19	23	25	10	23	12	13	22
		E.R.	1.96	1.52	1.52	1.08	0.96	0.78	0.72	0.84	1.08	1.40	1.73	1.89
		% CH.	65	68	72	87	72	84	76	62	70	61	61	64

TABLE V—*continued.*

Rainfall Variability at Coastal Localities Expressed in Terms of the Percentage Chance of Receiving Stated Amounts of Rainfall Each Month *—continued.

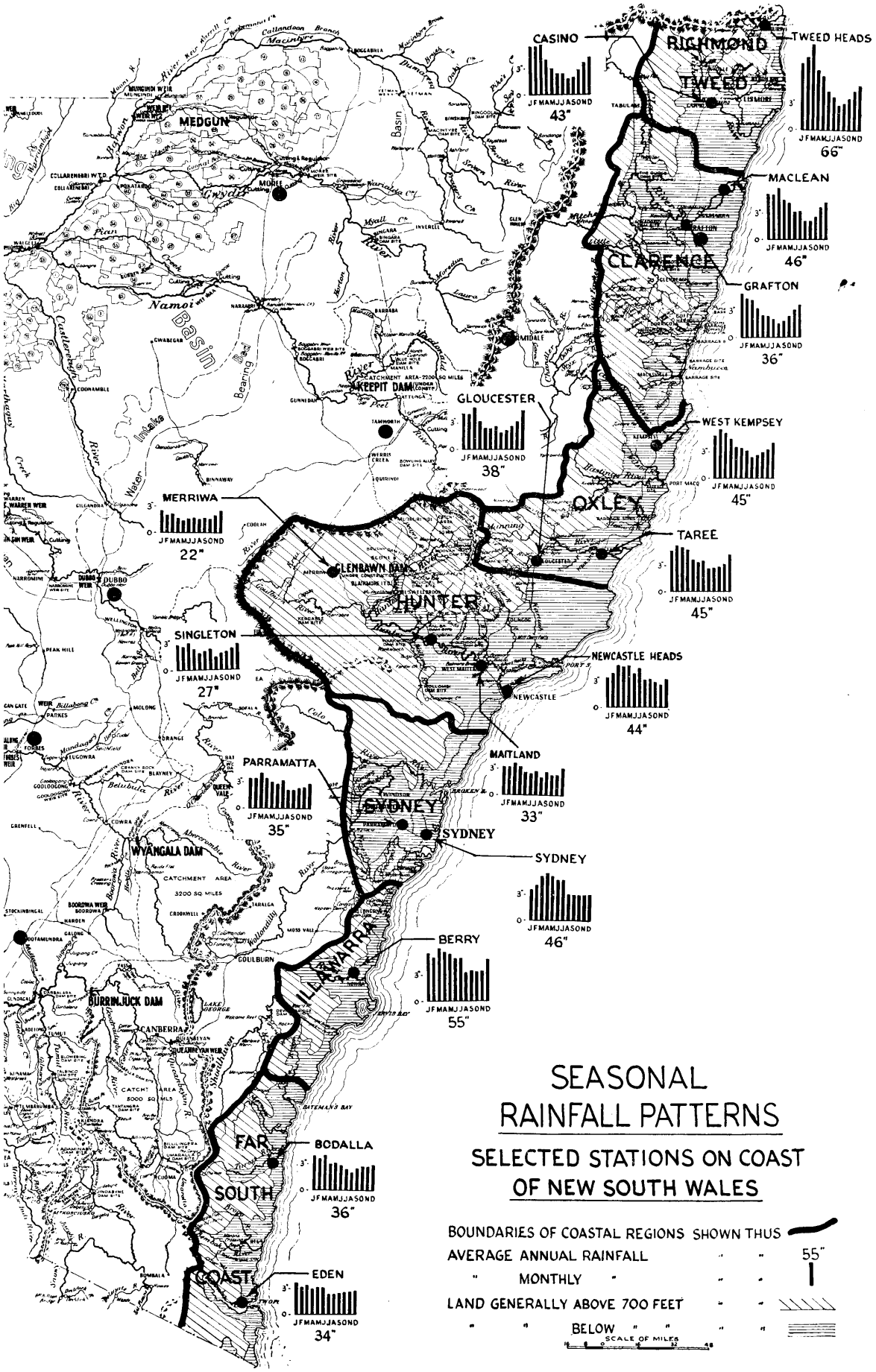
Region.	Station.	Amount of Rainfall.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		inches.												
Sydney	Campbelltown ...	1	82	67	84	75	68	59	67	57	67	74	70	79
		2	56	47	56	49	39	39	44	30	35	33	44	51
		3	35	32	33	28	25	27	30	15	16	16	24	35
		4	21	20	22	17	19	20	22	10	7	10	10	23
		E.R.	1.84	1.57	1.46	1.18	0.92	0.76	0.77	0.92	1.20	1.47	1.68	1.84
		% CH.	58	55	70	70	68	70	73	59	60	56	53	56
Illawarra	Berry	1	95	90	89	93	88	79	79	60	80	85	80	89
		2	75	74	77	81	66	59	63	39	61	56	58	72
		3	58	58	65	66	52	47	50	30	44	38	42	55
		4	48	45	54	52	42	40	41	23	31	28	30	43
		E.R.	1.82	1.47	1.40	1.20	0.99	0.78	0.75	0.96	1.11	1.40	1.52	1.84
		% CH.	79	83	84	91	89	83	84	61	78	77	68	75
Far South Coast ...	Bega	1	84	64	70	68	61	66	50	53	61	75	74	75
		2	63	42	50	45	39	45	28	32	33	48	38	53
		3	43	29	32	31	26	33	20	21	18	28	25	37
		4	30	20	24	24	17	25	16	16	13	19	15	28
		E.R.	1.78	1.48	1.30	1.12	0.92	0.85	0.80	0.84	1.19	1.22	1.46	1.78
		% CH.	68	55	63	63	62	70	58	58	52	67	54	58

* Figures obtained from the Commonwealth Meteorological Bureau.

1 inch, 2 inches, 3 inches, 4 inches } Percentage chance of receiving the stated amounts—1 inch, 2 inches, 3 inches and 4 inches, during each month of the year, based on an analysis of long period observations.

E.R.—" Effective " rainfall amounts—amounts necessary to maintain plant growth above wilting point each month (as inches).

% CH.—Percentage chance of receiving amounts equal to or greater than the " effective " amount for each month.



MAP I.

Source : Report of the Irrigation Development and Food Production Advisory Committee, Part III, op. cit.

† 34615—6