INTEGRATION OF IRRIGATION AND DRYLAND FARMING IN THE SOUTHERN MURRAY BASIN*

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PART I: NEED FOR REAPPRAISING THE CONCEPT

1. SUMMARY

This article is the first of a series of studies on irrigation farming in the southern Murray Basin. Its primary purpose is to emphasise the need for a new appraisal of the value of better integration between irrigated and dryland production as a means of combating production uncertainty. Attention is focussed on group irrigation "areas" and "districts" mostly under

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Government control. The irrigated area within these projects of the southern Murray Basin accounts for about 80 per cent of the irrigated acreage in Australia.

After a decade of comparatively bountiful seasons which began in 1946, the southern Murray Basin experienced a reversal of conditions in 1957 and this greatly renewed interest in the vexed problem of production uncertainty for which Australia is unique among the continents. This article demonstrates how better ties between irrigated and unirrigated economies might help to mitigate some of the effects of this uncertainty. However, it is not the aim of this study to prove that integrated systems of agriculture are necessarily the most "desirable" projects to sponsor in national development. Even when viewed narrowly as only a problem in economics, there is insufficient experience to substantiate this. The same lack of data prevents any detailed assessment of the economic merits of integration in current irrigation schemes. Insofar as it relates to developmental policy, this article stresses that there are strong *a priori* reasons for believing that experimental research should be conducted to evaluate ways of encouraging a fuller integration between irrigated and unirrigated uses of land, and there is the corollary need to explore new institutions of land management to help overcome a traditional imbalance between these two sectors of the economy. This argument is based primarily on three features of the Australian situation:

(i) A relative abundance of land, the development of which is handicapped by a dearth and uncertainty of water resources.

(ii) An apparent comparative advantage in the production and sale overseas of products from broad acre industries.

(iii) The limited contribution of existing irrigation schemes to combating production uncertainties.

It is emphasised that it is erroneous to pursue the tradition of identifying the concept of integration only with existing systems of "partial" irrigation now developed in parts of southern New South Wales and northern Victoria. These projects have met with a number of developmental problems. In addition, they have tended to assist resource development in limited areas over the long-run rather than promote greater production flexibility and stability in dryland agriculture. As a consequence there is considerable doubt about their suitability for future expansion in other areas. At the same time, alternative development of irrigation by "intensive" projects has also encountered difficulties, particularly in the economic disposal of some of the produce (*e.g.*, fruits and butter). There has been the added difficulty that exchanges of fodder and livestock between these projects and dryland economies, faced with the impact of production uncertainties, have been sporadic and often non-existent, because of the types of production undertaken by many "intensive" irrigation projects and the fact that the two elements of the economy are largely under separate management.

If it is desired to sponsor group irrigation schemes to assist greater stability and flexibility of dryland farming as a primary objective, more thought might be given to the merits of developing projects which combine the best elements of current "partial" and "intensive" projects. Thus, there is the need to experiment with a system of "spatial diversification" in which irrigation is developed by the "solid-block" principle in compact areas along "intensive" lines but linked under joint management with the development of drylands, nearby or at a distance. The irrigated tract would probably be best developed near to major diversional points on the higher rainfall sectors of the riverine plains where soils and water-supply conditions allow greater flexibility of land use. Compact development in these areas would promote efficiency of water distribution. At the same time, this would imply that the irrigated land might have to be linked with more remote drylands located in areas with the greatest uncertainty but normally not adjacent to the best sites for "intensive" irrigation. The dryland farmers could be given the same rights to use portions of the irrigated tract as they would have to use irrigated lands developed on their own farms in a "partial" irrigation district of the traditional type.

To overcome the much-voiced criticism that dryland and irrigation farming do not mix effectively, attention could be directed to the possibility of encouraging corporate farmer management of either the irrigated tract or the drylands, or both, so that adequate attention could be paid to the peculiar demands of each sector of the integrated economy. The Grazing Associations of farmers developed in parts of the United States might provide a guide here.

Whether more active integration (with or without corporate land management) would work in Australia is still a matter for conjecture. Its merits could only be assessed in an experimental project conducted over a fairly long period of years. It would be unwise, however, at this juncture to dismiss techniques for promoting more active integration as unsound on the grounds of experience so far with irrigation in Australia. It is quite likely that novel institutions will have to be evolved if we are to meet adequately the "challenge of production instability". Some of the projects being planned for the Murrumbidgee Valley should provide a valuable indication of the practicability of the system of integration suggested in this article.

2. INTRODUCTION

The conservation of water and its use by irrigation to offset the deficiencies of rainfall have always been vital problems in Australia because considerable areas of potentially fertile land are greatly reduced in productivity by a paucity of water resources. Knowledge of the physical geography of the continent is sufficiently advanced for there to be little hope that irrigation will ever enable the bulk of primary production to achieve a large measure of independence from rainfall, unless artificial measures are evolved to greatly alter the character of rainfall. However, developments so far, and the presage of major projects over the next several decades, in both the sub-humid and semi-arid areas, indicate that irrigation will play a vital role in company with other techniques towards reducing the impact of production uncertainty.[1]

[1] The significance of this general problem has been emphasised by Keith O. Campbell in "The Challenge of Production Instability in Australian Agriculture", Presidential Address, *The Australian Journal of Agricultural Economics*, Vol. II, No. 1 (July, 1958), pp. 3-23. He makes brief mention of the possibilities of developing "spatial diversification" and new systems of land management—concepts elaborated in the present paper.

Whilst irrigation on a private and small-scale basis is fast achieving marked success in many quarters, a striking feature is the degree to which the conservation of water and its use for irrigation are under direct government control. It will be shown later that this stems principally from a physical environment which demands large investment in water storage and reticulation as well as active control of water use to ensure equitable distribution as well as an adequacy and continuity of supply. The high level of government participation in irrigation programmes has had a number of effects including two of direct relevance to this discussion:

(i) Much of the irrigation farming has involved group settlement unless conditions of water supply were inimical to this.

(ii) Whenever the occasion has warranted it, irrrigation has been used as an essential basis for State-sponsored closer settlements deliberately aimed at maximising the level of new farming opportunities for aspirant settlers with limited capital. Large immigration programmes were early corollary features of this resource development.

These conditions have meant that many irrigation settlements have tended to displace rather than serve the needs of older dryland uses. However, this is by no means general because active systems of "partial" irrigation have been designed to cater for the requirements of pre-irrigation farming in riverine plain country surrounding many of the closer settlements, and there has been some interplay between the latter and unirrigated farms.

Because land will always be much more abundant than water in Australia and because the products of broad acre farming (*e.g.*, wool, sheepmeats, beef and coarse grains) tend to offer better long-term economic prospects than do those from more intensive culture (*e.g.*, fruits and butter), the relationship between irrigated and dryland farming will always remain an important theme in Australia's development. The concept of integration discussed in this paper is not a new one in this country; in fact, Australia has led the world in developing many features of integration by its projects on the riverine plains of the southern Murray Basin. This series of articles will provide an outline of the salient features of integration in present projects and will emphasise some of their deficiencies in this respect. It will be stressed that the characteristics of Australia's climate and the location of suitable soils and water resources for large group projects may require novel systems of land management, if integration is to be developed to the maximum advantage, *i.e.*, if water is to benefit the largest proportion of broad acre production consistent with maximising overall net income.

The present article is designed to achieve two ends: firstly, to pinpoint certain features of production uncertainty in the southern Murray Basin; secondly, to summarise the meaning of the concept of integration and its value in an Australian setting. A subsequent article will provide a geographical appraisal of regional contrasts in the character of integration based on a study of the area over recent years. It should be stressed, however, that integration is only one problem which needs to be considered along with many other issues of a technical, social and economic kind when planning irrigation projects.[2] The relative merits and demerits of various systems of integration, including a novel one suggested in this article, cannot be tested with available data. This would require an experimental project over a period of years.

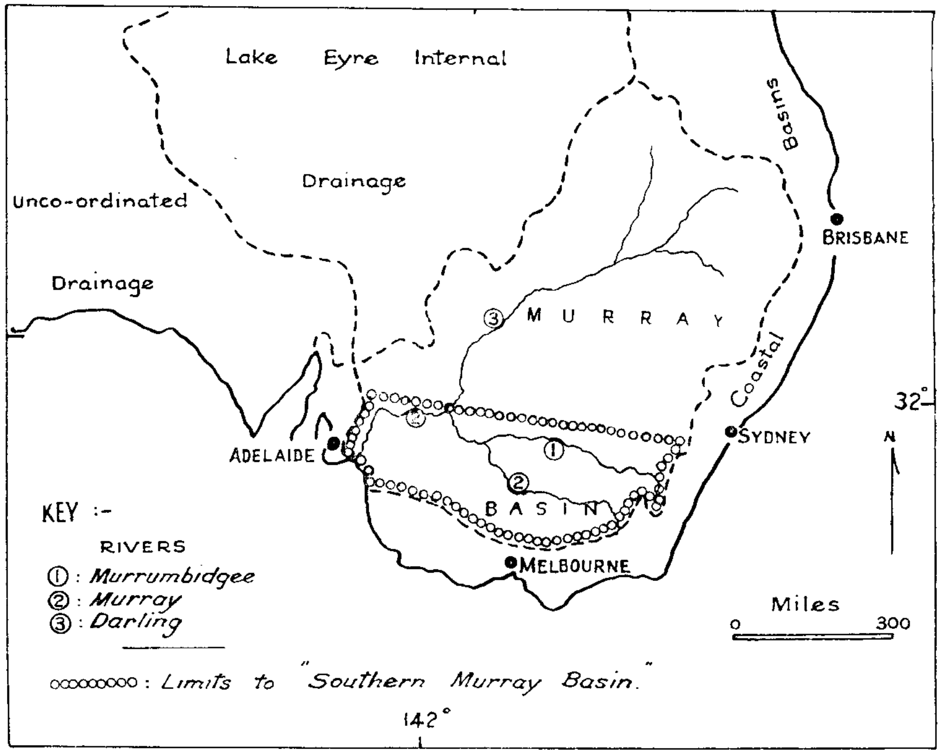

Fig. 1. Location of "Southern Murray Basin" in relation to Murray Basin and adjacent Drainage Basins

Definitions

The following is a definition of some of the terms used in this article.

SOUTHERN MURRAY BASIN: The Murray Basin is shown on Figure 1 and will be familiar to most readers. The "southern Murray Basin" comprises that portion of the Murray Basin (sometimes referred to as the Murray-Darling Basin) which lies *south* of the northernmost latitude of the Murrumbidgee Valley. The region is dominated by the Murray River and the country "drained" by its major tributaries in the winter-rainfall zone, *i.e.*, the Murrumbidgee (N.S.W.), Goulburn, Campaspe and Loddon (Victoria), as well as the Mallee country on both sides of the Victorian and South Australian border. Portion of the lower western lands, Lachlan River and

[2] For example, see *The Report of the President's Water Resources Policy Commission,* Vols. 1, 2 and 3 (Washington: Government Printer, 1950). *Also*: Report of a Panel of Experts, *Integrated River Basin Development* (New York: United Nations, Department of Economics and Social Affairs, 1950).

Darling River valleys, are also included in New South Wales. Figure 2 shows the statistical divisions falling mostly within the "southern Murray Basin". It will be seen that these comprise:

New South Wales: Southern Tableland, South-western Slope, Riverina and lower Western Division.

Victoria: North-east, Northern, North Central, Wimmera and Mallee.

South Australia: Murray-Mallee.

We are concerned in this article principally with riverine plain and Mallee country inland from the Great Dividing Range and Mount Lofty Range (*i.e.*, country inland of the 600 feet contour line) which delimit so much of the southern Murray Basin to the east, south and west. In other words, attention will be focussed on those Statistical Divisions which have been underlined. Within these are to be found most of the group settlements for irrigation and some 80 per cent of the irrigated area of Australia. The country has an average annual rainfall of about 20 inches on the peripheries to the east, south and west, which declines towards the north-west down to less than 10 inches.

IRRIGATED LANDS: Irrigation in the southern Murray Basin tends to fall into two elements. First, most development is to be found in group settlements called "Irrigation Districts" or "Irrigation Areas" and, with few exceptions (notably at Mildura and Renmark), is under direct State control. Second, a minor but growing aspect of the development is undertaken by "private diverters" on a small-scale and essentially individualistic basis. Whilst this offers much promise as a means of promoting more integration, this study is concerned solely with the first type of development. All reference to irrigated land is to land watered in "Districts" or "Areas".

INTEGRATION: For the purposes of this discussion, land uses are said to be integrated if:

(i) Irrigated and unirrigated lands are used by the same farm in a system of *"on-farm" integration,* and/or

(ii) Products of irrigated land use are sold to farms not irrigating and *used as factors of production* by them or *vice versa* in a system *of "off-farm" integration.* This study is not concerned with more indirect links between the two economies (such as the influence of institutions developed in "irrigation" towns).

Integration does not necessarily imply scattered water distribution for "partial" irrigation as will be shown in this article.

FARM: The term "farm" is used to mean the complete business enterprise even though this might embrace a number of land units each of which could be termed a "farm" by some other definition. The land components need not be contiguous.

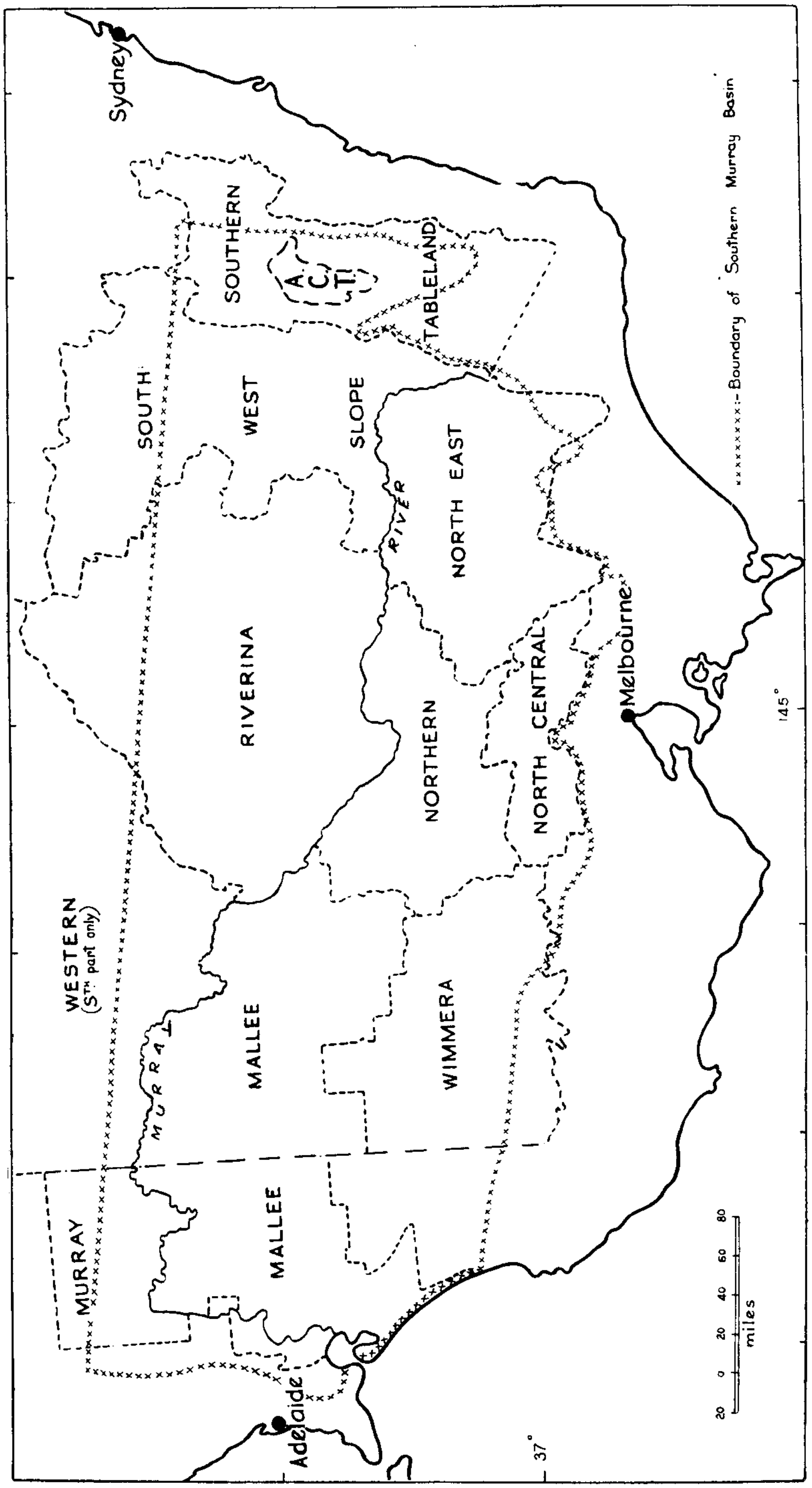

Fig. 2. Statistical Divisions of Southern Murray Basin

TYPES OF IRRIGATION: The terms "intensive", "extensive" and "partial" are used in Australia to describe different systems of irrigation.[3] In this article the last two are used as interchangeable and are distinguished from the first as follows:

"INTENSIVE": This applies to an irrigation "district" or an irrigation "area" with a 1 in 1 or better *pro rata* water right (*i.e.*, landholders are entitled to the supply of at least 1 acre-foot of water per annum for every acre considered by the supplying authority to be suitable for irrigation and commanded by the general works). Included are private group schemes or other public schemes which enjoy similar levels of water supply. In the "intensive" districts or areas most of the *productive* land is irrigated.

"EXTENSIVE OR PARTIAL": This applies to districts with lower water rights in which appreciable areas of productive land are not watered.

SPATIAL OR AREA DIVERSIFICATION: This concept means the grouping of different types of country, suited to different forms of production, within the control of each farm operator. As used in this article, it means the integration of irrigated and non-irrigated lands (adjacent or separated) to achieve in semi-arid areas the advantages of traditional enterprise diversification normally more successfully developed in humid climates.

HUMID, SUB-HUMID AND SEMI-ARID CLIMATES: For the purposes of this article, these climatic types are defined on the basis of average annual rainfall conditions and embrace the following areas of the southern Murray Basin:

HUMID: Areas with more than 25 inches A.A.R.
SUB-HUMID: Areas of 15-25 inches A.A.R.
SEMI-ARID: Areas with less than 15 inches A.A.R. (more than 8 inches).

The group irrigation schemes all occur in the latter two zones, whilst the humid zones correspond to the upland water-catchment regions flanking the irrigated plains and Mallee.

DRYLAND: This term applies to farming in country not embraced by the group irrigation projects and dependent mainly on rainfall, although some scattered irrigation is practised by "private diverters".

3. IRRIGATION FOR RESOURCE DEVELOPMENT OR PRODUCTION STABILITY?

Irrigation can have widely different effects on the character of rural production but any project involves a critical choice between maximising resource development in limited areas or contributing to maximum stability and flexibility of production on farms over wider areas without the same

[3] The concepts of "intensive" and "extensive" irrigation are referred to in R. O. Kefford, "Intensive or Extensive Irrigation", *Aqua,* Vol. 1, No. 7 (March, 1950), pp. 9-15. John H. Shaw, "Land Use in Deniliquin Region", *The Australian Geographer,* Vol. VI, No. 2 (March, 1953), pp. 31-37.

degree of resource development. At one extreme, irrigation may assist a complete change in the character of farm production allowing "exotic" forms of land use and providing an assured basis for closer settlement with considerable increases in production per acre and population densities—this is termed resource development. At the other extreme, irrigation may be used merely to promote greater stability of farm incomes within an existing economy, without stimulating marked changes of the aforementioned kind. There are numerous intermediate cases.

A notable characteristic of irrigation projects in most areas of the world is the emphasis which has been placed on resource development as irrigation has been used "to make the desert blossom like the rose". Often under political pressures for new farming opportunities, irrigation has been employed to underwrite closer settlements lacking direct integration with surrounding dryland economies and comprising small-scale family farms producing fruits, vegetables and dairy products, usually for a distant market. In most cases, these have been activities which could not be sustained over the long run as commercial enterprises of any note without irrigation several times the normal rainfall. Often, concomitants of these developments have been politically contrived systems of "cheap" water supplies and interference with the free market mechanism by various price support measures.[4]

Periodically, dryland farmers producing cereals, sheep and beef cattle, have made claims to share in group irrigation projects, but their interest has tended often to be both erratic and ephemeral. Nevertheless, large-scale attempts have been made in some areas. notably the southern Murray Basin, to encourage, as a primary aim, more active links between irrigated and dryland farming, notably by creating "districts" of "partial" irrigation without closer settlement. These aimed to encourage a better flexibility and stability of production in industries geared basically to rainfall. The "partial" irrigation projects have met with variable success and it is the current policy of Governments in eastern Australia to use additional waters becoming available in the Goulburn, Murray and Murrumbidgee rivers to greatly modify the intensity of land use within existing "partial" irrigation districts or to develop new "intensive" irrigation areas with property resumption and controlled subdivision for closer settlement; integration is only a secondary aim of these projects.

Only during recent decades has much systematic attention been given in countries like the United States and Australia to the question: *"How can irrigation on a group basis be used to promote more flexibility and stability in systems of production already developed throughout areas of climatic uncertainty?"* It is in this latter context that the concept of integration discussed in this paper has its greatest significance. Judging from progress made so far in Australia and the United States, co-ordinated development of irrigated and dryland economies at the level of primary production could make a valuable contribution to mitigating climatic uncertainty as well as

[4] A brief discussion of these and other measures in Australia (for irrigated and other products) is given in: J. N. Lewis, "Agricultural Price Supports—A Classification of Measures Operating in Australia", *Economic Monograph,* No. 207, The Economic Society of Australia and New Zealand (New South Wales Branch), May, 1958.

inducing certain technical advances. *However, it seems that novel institutions of land control may have to be considered if this is to be achieved as a primary goal of group irrigation settlements* so as to avoid the disadvantages of traditional systems of "partial" irrigation by scattered water distribution.

Historical Perspective

A brief examination of the history of irrigation developments in the southern Murray Basin will emphasise certain salient features of growth of projects undertaken so far.[5] Much of the initial interest in water conservation and irrigation in south-eastern Australia developed during the late 1870's and 1880's among the graziers and newly-established cereal growers of northern Victoria who were faced with the onset of drought.[6] This followed in the wake of a run of good seasons for arable farming which had encouraged a wave of closer settlement of the interior plains after the initial Gold Rushes. An early emphasis on wheat growing at the expense of livestock was a reflection of both the small size of holdings (320 to 640 acres) and the fact that wheat enabled landholders to meet better the high costs of clearing and maintenance. For these settlers artificial water supplies were sought as a means of stabilising dryland production. A large number of Water Supply Trusts (Domestic and Stock and later Irrigation) were established to implement schemes of water conservation and irrigation with State assistance in the form of loans and the construction of a number of National Headworks. These Trusts ran into financial and administrative difficulties and proved an ephemeral approach to the problem of achieving a workable means of promoting large-scale water supply and irrigation projects. The early part of this century ushered in a new era of "State Socialism" in this field in Australia as State Governments assumed control over development. The "nationalisation" of major water resources (*i.e.*, surface streams), State construction of major headworks and administration of most group irrigation and water supply districts, as well as the implementation of systems of "compulsory water rights" and rotational deliveries of water, were keynotes of this new phase which have persisted to the present day. The dictates of physical conditions in Australia, notably the highly variable rainfall, a necessarily high ratio of storage capacity to irrigation needs, the long distances between storage sites and irrigable areas and a lack of coincidence between peak river flows and irrigation seasons, have been important factors influencing an early appreciation of the need for State action in the major projects of water conservation and irrigation. Most of the development in south-eastern Australia has been conditioned very greatly by the State Rivers and Water Supply Commission of Victoria and the Water Conservation and Irrigation Commission of New South Wales. The Lands Department of South Australia has also played an important role in that State.

[5] It is intended to present a more elaborate study of the history of irrigation farming in south-eastern Australia in a later issue.

[6] A brief account of land settlement in portion of the northern plains of Victoria is given in: *Reconnaissance Survey of the Sheep Industry. 8. The Counties of Tatchera and Gunbower, Victoria* (Canberra: Bureau of Agricultural Economics, 1952), pp. 1-2. See also: L. R. East, "Irrigation in Victoria—The First Hundred Years", *Aqua*, Vol. 5. No. 10 (June, 1954), pp. 7-19.

One significant result of the predominance of State Government activity in major water projects is that it has allowed State land settlement policy and the political and social motives underlying it to greatly affect the character of schemes completed so far. Another important result is that the implementation of different State policies has made for quite remarkable contrasts of development between different parts of irrigable lands which lie within several States but present similar physical resources. The asymmetrical patterns of settlement along the Murray on the riverine plains of northern Victoria and southern New South Wales are striking examples of this.[7] Contrast for example the relative emphasis on intensive land settlement in northern Victoria with more extensive settlement in southern New South Wales.

Significant features of development this century, under State control or influenced by it, have been the numerous closer settlements promoted with irrigation. These formed part of a much more general and longer process of closer settlement of lands which began in the 1880's and persisted at an uneven rate until recent years. It was actuated principally by a strong political move to "unlock the land" and provide greatly enhanced farming opportunities for aspirant settlers. Very active immigration schemes and War Service Land Settlement projects were features of the process after 1910.

Greatly influenced by the success (despite initial setbacks) of the fruit settlements of the Chaffeys at Mildura and Renmark and by the planning and submissions of administrative and engineering advisers such as Elwood Mead,[8] State Governments in south-eastern Australia implemented a policy of establishing numerous closely-knit irrigation communities of family farms producing for a distant market. By these means, the frontiers of intensive farming were carried from the humid and sub-humid lands out on to the semi-arid and dry sub-humid interior riverine plains and Mallee country of the southern Murray Basin. Between 1910 and 1930, closer settlement projects were used to establish most of the Nation's dried fruits and canning soft fruit industries, and significant sections of its citrus, wine and dairying industries. These developments occurred along the Murray River and its most important tributaries in the winter rainfall zone—*i.e.*, the Murrumbidgee and Goulburn—and lesser streams like the Campaspe and Loddon. This produced compact and often isolated but highly productive and populous communities.

Around the various "islands" of closer settlement forming the nuclei of newly-developed irrigation farming, surplus waters for irrigation and the various rights and obligations attached to them were pushed into dryfarming

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[7] These patterns have been emphasised by J. Macdonald Holmes, *The Murray Valley* (Sydney: Angus and Robertson, 1948).

[8] Elwood Mead was an American who spent a lifetime in the field of water conservation and irrigation in both the United States and Australia. He had a profound influence on the shaping of Government policy in Victoria and the rest of Australia, to the extent that Victorian precedent was followed by the other States. Following his role as Chief of the Irrigation Investigations Bureau in the U.S. Department of Agriculture, he became second Chairman of the State Rivers and Water Supply Commission of Victoria, from 1907 to 1915. After his return to America he held a university post in California and eventually became Commissioner, Bureau of Reclamation. See: Elwood Mead, *Helping Men Own Farms, A Practical Discussion of Government Aid in Land Settlement* (New York: The McMillan Company, 1920). I. G. Baker, "Elwood Mead in Australia, An Historical Survey", *Aqua*, Vol. 2, No. 6 (February, 1951), pp. 3-11.

areas—many already embraced by earlier Trust districts—producing livestock (mainly sheep) and cereals (wheat, oats, barley, etc.). By these means, numerous "partial" irrigation districts emerged or were consolidated, chiefly on the northern plains of Victoria. In these projects, irrigation land use has tended to develop into much more than a mere supplement to dryland farming. In many areas, it has encouraged the persistence of a settlement pattern more intensive and diverse that would be possible under rainfall alone. Relatively small properties (in northern Victoria, many were between 320 and 640 acres) came to rely on irrigation as basic to their continued existence and eventual emergence as specialised fat lamb producers.

It would seem that the various "partial" irrigation districts not subject to closer settlement have never been viewed with as much favour by the politician, the irrigation engineer and the agricultural scientist as have the more intensively farmed closer settlements.[9] In the latter, small farms, high gross production per acre, higher "efficiencies" of water distribution and greater population densities have been regarded as indices of the "most economic" form of development. By contrast, the comparatively haphazard use of water and farming techniques in the "partial" irrigation districts has been coupled with an alleged lower output per acre irrigated and lower population densities as measures of the "least economic" form of development.

Especially as increased water supplies have become available, more recent Government policy has been to encourage an intensification of land use within existing "partial" irrigation districts south of the Murray, rather than develop similar schemes in new areas. The aim has been to promote forms of production and/or intensities of resource use more along the lines of the closer settlements which have been used as ideal models. As a consequence, irrigated land has come to play a much more dominant role than in earlier years and the importance of dryland has receded. This process is still going on. It will be shown in a subsequent article that this has encouraged a decline of "on-farm" integration *but an increase of actual and potential "off-farm" integration.*

North of the Murray, the "partial" irrigation schemes developed along somewhat different lines to those of earlier years south of the river. Partly because of the marketing and land management problems which followed in the wake of closer settlement on the Murray, Goulburn and Murrumbidgee, and largely because of the runs of drought conditions during the thirties and forties, a much more cautious approach towards irrigation projects was implemented during these decades in the Riverina. State development projects went to an opposite extreme in that very "extensive" systems of "partial" irrigation were encouraged, first in the Wakool and Berriquin Irrigation Districts and plans of an earlier decade were materialised later in the Denimein and Deniboota Irrigation Districts. The initial aim was to spread water over large areas of country, without property resumption, to provide the maximum number of existing settlers with enough water to irrigate a small fraction (initially an average of one-tenth) of their commanded and suitable lands. These projects sought initially to provide a drought insurance for wool growing and some erratic fat lamb production, but they had the effect of

[9] This seems to be more evident in Victoria than in New South Wales, and was particularly noticeable in the doctrines espoused by Elwood Mead.

allowing a more effective, stable and specialised production of fat lambs in all years, hitherto inhibited by frequent checks in feed supplies at strategic periods. The initial aim was not to encourage intensification of the pattern of land use and watered land was to be purely supplementary to dry land. However, intensification of the land use has tended to occur even on the basis of insecure water supplies (see reference to Willoughby on p. 278). Of course, there is no difference in principle between these "partial" irrigation projects north of the Murray and those developed south of the river in the previous four decades. However, an important difference in operation was that irrigation in the Riverina was used initially on much larger farms geared more to rainfall (with lower "water rights") than was the case in northern Victoria.

None of the "partial" irrigation schemes of the southern Murray Basin have had the same spectacular appeal as the closer settlements for fruit growing and dairying, established mainly in the fifteen years after 1910, but to a lesser extent in the late 1940's. They resulted in no striking metamorphosis of the landscape, although they have induced important if subtle changes in the character of farming over wide areas. However, the frequency of poor seasons to 1945 encouraged a growing consciousness of the need to use irrigation as an instrument for dryland settlement and, by the early post-war years, there is no doubt that the principles inherent in the concept of integration were widely discussed in Australia, even if they were not crystallised into the terms or analytical framework used by American economists and mentioned later in this article (see pp. 267-70). Nevertheless, it should be remembered that the appeal of the concept of irrigation to assist dryland farming was probably based not so much on a belief in the intrinsic value of integration as on a reaction to the fact that earlier closer settlements for fruit and dairying had led to serious developmental problems of a physical and economic kind.[10] There has since been a reaction against "partial" irrigation by scattered water distribution.

During the decade of good seasons for non-irrigated farming after 1945, the notion of integration through "partial" irrigation tended to lose favour and recent official statements on likely developmental projects in the southern Murray Basin over the next several decades indicate a resurgence of the principles of closer settlement. However, some vital modifications have been made to earlier models and a more flexible system of land use which could encourage integration as a secondary objective is featured in recent proposals designed to stimulate production of sheep and beef meats and broad acre crops.[11]

[10] The physical problems, in the form of high water tables, "salting", and breakdown of soil structure were particularly evident in districts like Cohuna and Kerang. Economic problems were universal to all the dried fruit areas.

[11] *First Report of the Committee Appointed by the Minister for Conservation to Advise on the Use of Additional Water Available within the Murrumbidgee River Upon Completion of Blowering Dam* (Sydney: Government Printer, 1956). This report is referred to in some detail on pp. 282-3.

Scope for Novel Development

To a large extent, the planning of irrigation projects must be made within the framework of existing trends in production and techniques of resource use and knowledge of past experience. Whilst it can pay close attention to immediate and likely short-run future marketing considerations as well as a knowledge of the impact of soil and topography on the suitability of land for irrigation, planning cannot accommodate all possible future land use developments. In this situation, a prime aim should be to promote, at the outset, a reasonably flexible system of water supply and irrigated land use capable of adapting itself to possible changing patterns of agriculture in the future. This would involve the selection of soils, the allocation of water resources, the installation of adequate irrigation works and the development of farm sizes, all of a kind which would permit a relatively wide range of land uses, so as to allow any desirable changes. It is encouraging that these considerations have received considerable weight in the recently announced policy for irrigation development in parts of the southern Murray Basin.[12]

Notwithstanding the merits of current proposals, a problem still remains to be considered. The efforts of the architects of irrigation schemes in Australia have so far been directed primarily to a choice between two kinds of development: (i) closer settlement with "intensive" irrigation in compact areas for essentially self-contained production of fruit and dairy products without integration in the first instance, but with rice and fat lamb raising and some "loose" integration in later areas, *or* (ii) a "loosely" integrated system of "partial" irrigation for sheep farming such as the Irrigation Districts of the riverine plains, which has involved scattered water distribution with its attendant problems of water losses, erratic use of water and relatively inflexible land use. As far as the writer is aware, little or no attention has yet been given to promoting a project which combined the best elements of these two traditional systems, *i.e.*, "intensive" irrigation in compact areas linked by management ties with dryland areas, nearby or at a distance. A corollary feature of such a system might be novel methods of land management to ensure efficient use of resources, although this is not a necessary element of a new approach to integration.

Bearing in mind the economic and technical merits of compact and intensive irrigation on well drained soils on the fringes of the riverine plains (often quite remote from dryland areas with the greatest production uncertainty), it should be possible to develop a compact irrigation district by the "solid block" principle but integrate the use of this land with other dryland areas by a system of "spatial diversification", even if this involves linking non-contiguous lands. Dryland farmers could be given similar rights to parts of the irrigated tract as they would have to irrigated land developed on their own farms by the traditional system of "partial" irrigation. However, because irrigation is no longer scattered, it could encourage the technical efficiencies of water distribution and project location sought by the promoters of closer settlements in the past. If it is argued that irrigation and

[12] See footnote 11.

dryland farming do not mix to produce effective resource use, then some consideration might be given to experimenting with a system of corporate land management, after the style of the Grazing Association of Montana,[13] which could control either the irrigated or the dryland farming sectors of the integrated project.

Although it raises vital political and social problems not considered in this article, there are several ways in which the promotion of a system of corporate land management might facilitate an integrated system of agriculture and encourage more effective resource use than following the traditional system of family farming without integration. These can be considered under two headings:—

(i) Efficiency of Resource Management

Different forms of production make different demands on the farmer in terms of management skills, forms of investment (*e.g.*, types of machinery) and the timing of physical effort. Thus effective management of irrigated lands calls not only for specialised skills but also for painstaking and constant attention. The demands of irrigated land use differ, often quite markedly, from those of most dryland farming and these, in turn, differ from one another. Thus, it is difficult to successfully combine irrigated fat lamb raising with dryland cereal cropping and wool production. Attempts to develop such an integrated system of farming in which both the irrigated and the dryland enterprises are emphasised (one not being a mere ancillary to the other) often meet with criticism, particularly from advocates of "intensive" water usage, on the grounds that this integration is inimical to the best use of water and irrigated land.

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[13] See quotation on pp. 265-6 from E. A. Starch, "Type of Farming Modifications Needed in the Great Plains", *Journal of Farm Economics,* Vol. XXI, No. 1 (February, 1939). Also N. W. Monte, *Grazing Districts of Montana—Their Purpose and Organisation Procedure,* Montana State College, Agric. Exper. Sta., Bull. 326 (September, 1936).

The need for novel systems of land management to enable a more effective long-run development of resources in the Great Plains of the United States has been discussed by a number of writers. Whilst due allowance would have to be made for the physical and cultural differences between these regions and the zones of climatic uncertainty in Australia, these discussions throw some light on the possible advantages which might accrue from modified systems of land control in Australia. For example, see Marion Clawson, "An Institutional Innovation to Facilitate Land Use Changes in the Great Plains", *Land Economics,* Vol. XXXIV, No. 1 (February, 1958), pp. 74-79. The promotion of Grazing Association control of land management is discussed also in the Report of the Great Plains Committee, *The Future of the Great Plains* (Washington: Government Printing Office, 1936), and Elmer Starch, "The Future of the Great Plains Reappraised", *Journal of Farm Economics,* Vol. XXXI, No. 4, Part 2 (November, 1949), pp. 924-925, and discussion by G. Montgomery (p. 929).

The diverse land ownership pattern prevalent in the Great Plains posed difficulties for graziers attempting to develop farms sufficiently large for economic operation. The grazing districts (associations) aimed principally to acquire control of grazing land and spread its use among members. Cooperative investment was made in fencing and developing water facilities whilst controls were exercised over the rate of grazing. This formed part of a general programme of combating problems of production uncertainty. See Harry A. Steel and John Muehlbeier, "Land and Water Development Programs in the Northern Great Plains", *Journal of Farm Economics,* Vol. XXXII, No. 3 (August, 1950), pp. 431-444.

Judging from experience in the United States (chiefly, it seems, in non-irrigated farming), problems of efficient development of different lands by integration or "spatial diversification" are sometimes overcome by developing a system of corporate land management along the lines suggested by Starch and quoted later in this article (see pp. 265-6). One sector of an integrated economy is developed more or less along traditional lines with land use under the control of separate operators. However, the other sector of the integrated economy is managed by an Association of the first land-holders; co-operation in the latter sector ensures that the peculiar demands of land management are met adequately without prejudice to effective land use in the first sector. Using the example of irrigation development, an integrated system could embrace an irrigated tract integrated with a dry-land zone. The irrigated area would be developed along intensive lines by the "solid block" principle and split up into a series of small holdings, each managed by a separate irrigator. To allow the irrigated land use to proceed effectively at the same time as sound development of the dryland sector, the latter would be controlled by an Association of the irrigators. The two sectors of the economy are worked as an integrated unit for their mutual benefit. It would seem that, in such a system, the Association can make better judgment of whether or not, and by how much, to integrate the irrigated and the unirrigated land uses than is made in sporadic exchanges between separately managed farms under existing systems of land development. At present, even where it is economic to pursue more integration, this often does not happen or happens too late because the dryland and irrigated sectors are under separate management, pursuing highly autonomous activities.

(ii) Reduction of Uncertainty

Later in this article, it will be shown that integration offers a means of promoting a reduction of production uncertainties, particularly in semi-arid areas. That this might be achieved more effectively by a system of corporate land management can be shown by an example. Corporate management might induce a better geographic spread of uncertainty and thus enable limited irrigation to have wider stabilising impact than unit farm systems of integration. The impact of production uncertainty occurs in a differential regional pattern, affecting some areas more than others in any one time period. If a given area of irrigation is linked with dryland production on a co-operative basis, it is capable of providing a greater stabilising effect than if it is split up under separate management between a number of farmers (*i.e.*, if each farmer controls his own integration independently of the others). This would only apply in cases where the impact of production uncertainty affected some farmers in the Association to a greater degree than it did others or it affected some when others were not affected at all.

Co-operative land management would also help to reduce production uncertainty and give higher long-term incomes if it led to other economies of scale, particularly the promotion of a more liquid capital structure through a reduction in the ratio of fixed to variable costs. Co-operation might also achieve other economies in fodder conservation. For example, storage costs and rates of deterioration of fodder are probably much lower in terminal storage sites than on individual farms.

The concept of corporate land management runs counter to the well developed tradition of family farming in Australia. However, the problem of water shortage is so great in many areas of semi-arid climate that new methods of land control might have to be considered by farmers before final decisions are made on developmental projects the outcome of which is very difficult to reverse whatever the shortcomings. The merits or demerits of the proposal put forward in this article would only be revealed in an experimental project.

The economic justification of integration irrespective of any new system of land control would rest primarily on whether or not it led to a better development of rural production in the face of production uncertainty than non-integrated systems of production. The economic case for integration requires testing within the general field of investigation into alternative ways and means of using water resources in combination with different types of land and with different institutions for using the products of watered areas. An example of the problem raised by integration is: What is the relative merit of using X acre-feet of water to produce Y units of stock feed used in either of the following systems of production? (i) on a relatively small area of irrigated land running a limited number of sheep or beef cattle fed to a high nutritional level and relying chiefly on irrigated feed, or (ii) on a number of larger farms running many more sheep fed to a lower nutritional level and relying on both irrigated and non-irrigated feed (at the same time or at different times in their growth).

An economic analysis of the value of irrigation to the sheep industry would show whether or not, under certain assumptions, a greater net income is generated by using irrigated feed to maintain stock at a high nutritional level than using the feed for a much larger number of stock fed to a lower level. It is on the possible merit of the latter approach that the concept of integration relies for its economic justification. Unfortunately, too little is known as yet on the economic impact of production uncertainties and the economics of irrigation for even a crude guess to be made of the possible answer to this type of problem. It is not the purpose of this present study to attempt to arrive at such an answer. However, two aspects of the economics of integration are emphasised:

(i) The development of irrigated and dryland farming economies under systems of separate land management seems to lead to an unstable integration between the two and produces a relatively lower level of interplay than might be justified on economic grounds. Various institutional rigidities prevent this from being corrected by the market mechanism. This is particularly the case when fruit growing and dairying are sponsored as specialities under irrigation.

(ii) There is a tendency for the most suitable sites for irrigation to be somewhat remote from the dryland areas which might benefit most from an integration with them.

These two conditions would suggest that, if integration of irrigated and dryland farming is to be achieved as a prime goal of group irrigation projects, then consideration should be given to encouraging a linkage of non-contiguous lands in systems of joint management. However, an inevitable lack of juxtaposition of many land units and the problems of effective management of irrigated and unirrigated lands in joint control might require corporate management techniques for success.

Despite the general lack of empirical evidence to prove the case for more integration, there is some evidence to throw doubt on the merit of counter arguments. A comparison of stocking rates made by Gruen (see footnote to Table I) for the Berriquin Irrigation District in New South Wales and the Tongala-Stanhope Irrigation District in Victoria provides this type of evidence. His estimates were not made for the purpose of testing the economic merits of integration but they suggest that more rigorous tests are required before we accept as valid a number of "hypotheses" frequently put forward as "proof" of the ineffectiveness of integration. In terms of their natural environments, the Berriquin and Tongala-Stanhope districts are roughly comparable, particularly as regards natural rainfall and the suitability of soils to irrigation. On balance, it might be argued that, if all cultural factors are equal, one would expect stocking rates of both irrigated improved and unirrigated natural pastures to be about the same on the average as between the Tongala-Stanhope District and the Berriquin District. However, over-and-above the natural environmental conditions there are two cultural factors which would suggest that stocking rates should be higher in the Victorian District.

(i) The first is the fact that irrigated land use is much older in the Tongala-Stanhope District and has been conducted generally along more intensive lines than has been the case in the Berriquin District. To the extent that pastures improve in productivity both with age and with the intensity of water usage, one might expect higher carrying capacities in Tongala-Stanhope District than applied in the Berriquin District during the first decade of its development. However, the factor of intensity of water use is somewhat less vital than age of pasture because, even though water rights have been lower in the Berriquin District, water applications per irrigated acre have not necessarily been lower for similar types of pasture than in the Victorian District.

(ii) The second factor suggesting higher stocking rates in the Tongala-Stanhope District is that farmers there concentrate much more on irrigated land and practise less "on-farm" integration than is the case in New South Wales. If one is to accept the argument that "irrigated and dryland uses do not mix in an efficient way"—that "integration tends to encourage relative poor irrigated land use"—then one might look for lower stocking rates on irrigated land in areas where dryland is combined with it in significant quantities.

Bearing these factors in mind, it is interesting to compare the stocking rates for the two districts as computed by Gruen. His estimates apply to a sample of Tongala-Stanhope sheep farms for the period 1st July, 1946, to 30th June, 1949. In the case of the Berriquin District, his computations of stocking rates apply to a sample of sheep farms for the period 1949-50 to 1951-52, *i.e.*, to a time when irrigated pastures were still quite young and much of them would not have reached their full level of productiveness. Gruen's estimates for the Tongala-Stanhope farms and two groups of Berriquin farms are reproduced in Table I. The surprising feature of these estimates is that, despite the abovementioned reasons for expecting lower stocking rates on irrigated land in the Berriquin District, the reverse position applied. Gruen has suggested an explanation for this rather paradoxical situation chiefly in terms of the differences in the proportions of various types of pastures in the two districts, although some of the comparison is attributed possibly to differences in methods used for estimating stock equivalents. However, these estimates do not support the argument that integration has been inimical to efficient land use in the "partial" irrigation schemes of southern New South Wales. If anything, they suggest that integration has facilitated higher productivity on irrigated land in the Berriquin District than has been achieved by a more intense concentration on irrigated land in the Tongala-Stanhope district!

TABLE I

*Comparison Between Stocking Rates on Sheep Properties in Berriquin and Tongala-Stanhope Irrigation Districts**

Item (Averages)	Unit	Berriquin Irrigation District		Tongala-Stanhope Irrigation District
		All Farms	Small Farms	
Number of Crossbred Ewe Equivalents ..	Number ..	1,197·5	969·9	983·0
Area of " Dry " Land ..	Acres ..	913·6	520·8	123·0
Area of Irrigated Winter Pasture	Acres ..	178·1	149·3	206·0
Area of Irrigated Summer Pasture	Acres ..	32.7	35·8	72·0
Stocking Rate on " Dry " Land.	Crossbred Ewe Equivalent ..	0·49 (±0·02)	0·48 (±0·07)	0·96
Stocking Rate on Irrigated Winter Pasture.	Crossbred Ewe Equivalent ..	2·67 (±0·39)	2·71 (±0·48)	2·07
Stocking Rate on Irrigated Summer Pasture.	Crossbred Ewe Equivalent ..	6·88 (±1·44)	7·21 (±1·41)	4·26

* Estimates made from sample farm surveys: See F. H. Gruen, "Stocking Rates in the Berriquin and Wakool Irrigation Districts", this *Review*, Vol. 21, No. 2 (June, 1953), pp. 113-140.

This table can be interpreted in the following way, using the figures for the Tongala-Stanhope District as examples. The average farm in the sample possessed 123 acres unirrigated or "dry" land and 278 acres irrigated pasture land. On this were run 983 "cross-bred ewe equivalents" (*i.e.*, 983 ewes and 983 lambs). The computed average stocking rates per acre were: 0.96 "cross-bred ewe equivalents" for the "dry" land and 2.07 and 4.26 respectively for the irrigated winter and irrigated summer pasture.

The above comparisons should not be used to argue the case for traditional "partial" irrigation *per se*, since there seems no doubt that developments in this field have achieved much lower efficiencies of *water distribution* (*i.e.*, between major diversional points and irrigated land) than have more intensive water uses in some Victorian areas. Also, the stocking rates computed for the Berriquin District were probably based on more insecure intensification of irrigation using water in volumes over-and-above that which could be reasonably assured in dry years. In addition, a higher concentration on summer irrigated pastures in the Tongala-Stanhope District has meant that irrigated land use is probably much more flexible than it has been in the "partial" irrigation schemes of this State, wedded more to irrigated winter pastures. However, if these comparisons between the estimates of stocking rates can be taken as a valid indication that combining irrigated and dryland is not, by itself, inimical to high productivity of irrigated land, they suggest that it might be desirable to foster a combination of the two land uses *but* with irrigation in compact areas so as to permit the higher efficiencies of water distribution achieved by traditional "intensive" irrigation schemes. Such a system of integration is much less open to attack than is the "partial" irrigation scheme developed so far.

A criticism often levelled at the concept of integration is that "dry farmers display a very erratic demand for irrigation and this leads to both wastage of water in good rainfall seasons and to considerable difficulties in meeting the demand for irrigation in poor seasons". This seems to apply to sub-humid zones dominated by pastoral production where average rainfall is fairly high (15-20 inches per annum) and where the majority of seasons are fairly safe for animal production. However, if steps were taken to evolve the kind of integrated project outlined in preceding paragraphs, *i.e.*, one which embraced dryland areas with lower and more erratic rainfalls (*e.g.*, in the 10-15 inches average annual rainfall zone), it is most likely that a more stable demand would exist for irrigation. This is a key argument in support of "spatial diversification".

A system of integration (with or without corporate land management) should, *a priori*, enable landholders to make a better economic choice of alternative enterprises in the face of uncertainties on the production side. Take, for example, the comparison between two farmers running sheep or cattle for meat: Farmer A runs stock primarily on irrigated land, and Farmer B integrates irrigated land with drylands. Farmer A can breed his own stock for fattening or he can buy stores to fatten or he can do both. Fattening purchased stores is the most risky enterprise because the farmer must face both uncertainties in the supply (price) of stores as well as the price of fats. Under these conditions, Farmer A might elect to concentrate on the less risky enterprise, *i.e.*, breeding and fattening his own stock, despite the fact that higher net profits might be gained over the long-run by fattening purchased stores as a sole enterprise or in combination with his own breeding enterprise. For example, with beef cattle it appears that a better use of high-priced irrigated land can be made if stock are not bred on the irrigation pasture but young stock are brought on to it at a critical stage from which they can begin to make the most efficient conversion of pasture into beef.

In contrast to Farmer A, the second, Farmer B, who possesses both dryland pasture and irrigated pasture, is in a position to breed his own stores on the dry country and bring them on to the irrigated pasture if and when he desires to fatten them on this feed. Unlike Farmer A, he does not face the same degree of uncertainty in the supply (price) of stores and may elect to concentrate more on the relatively profitable combination of dryland breeding and fattening on irrigated land. Over the long term he would derive a higher net income, since he can achieve the benefits of conditions favouring dryland store production as well as those favouring fattening on irrigated land. In addition, he derives any economies to be gained by devoting irrigated land to young growing stock. This economic advantage of integration might have important repercussions on the sheep breeding industry now greatly handicapped by the long swings in seasonal conditions and the related supply (price) of store stock. That these advantages might outweigh any disadvantages of integration (*e.g.*, possible lower efficiency in the use of irrigated land) should be investigated more closely by those who now condemn integration as economically unsound.

The balance of this article is concerned with an examination of the conditions of production uncertainty which suggest that more thought should be given to integration in the southern Murray Basin. In addition, various types of integration are reviewed and some of the lessons from North American and Australian research are summarised.

4. THE IMPACT OF CLIMATIC UNCERTAINTY

The southern Murray Basin occupies a strategic position in relation to Australia's climate and its impact on land settlement, since it provides a cross-section of the major climates in the non-coastal lands of southern Australia—lands experiencing predominantly winter rainfalls from cyclonic activity. It embraces peripheral slope and plain country that have proved ideal for relatively intensive settlement without irrigation but, towards the north-west and north, on the inland side, it merges into regions which are much drier and less suited to intensive development without irrigation.

To the east, south, and south-west in the southern Murray Basin, sub-humid uplands (of the Great Dividing Range and Mount Lofty Range) abut the most densely populated areas of Australia. In the central areas, a dry sub-humid merging into semi-arid climate is experienced by riverine plains and Mallee country which have been the scenes of numerous attempts, some quite unsuccessful, to push the frontier of closer settlement for arable farming without irrigation beyond the more humid zones.[14] To the north-west, the plains come within the fringe of the belt of semi-arid country flanking the "Dead Heart" of Australia, a belt whose outer boundary has fluctuated markedly over time with consequent hardship for rural settlers.

[14] As witnessed by the problems of settlement of marginal wheat lands in South Australian Murray-Mallee, the north-western Mallee of Victoria and the western Riverina of New South Wales.

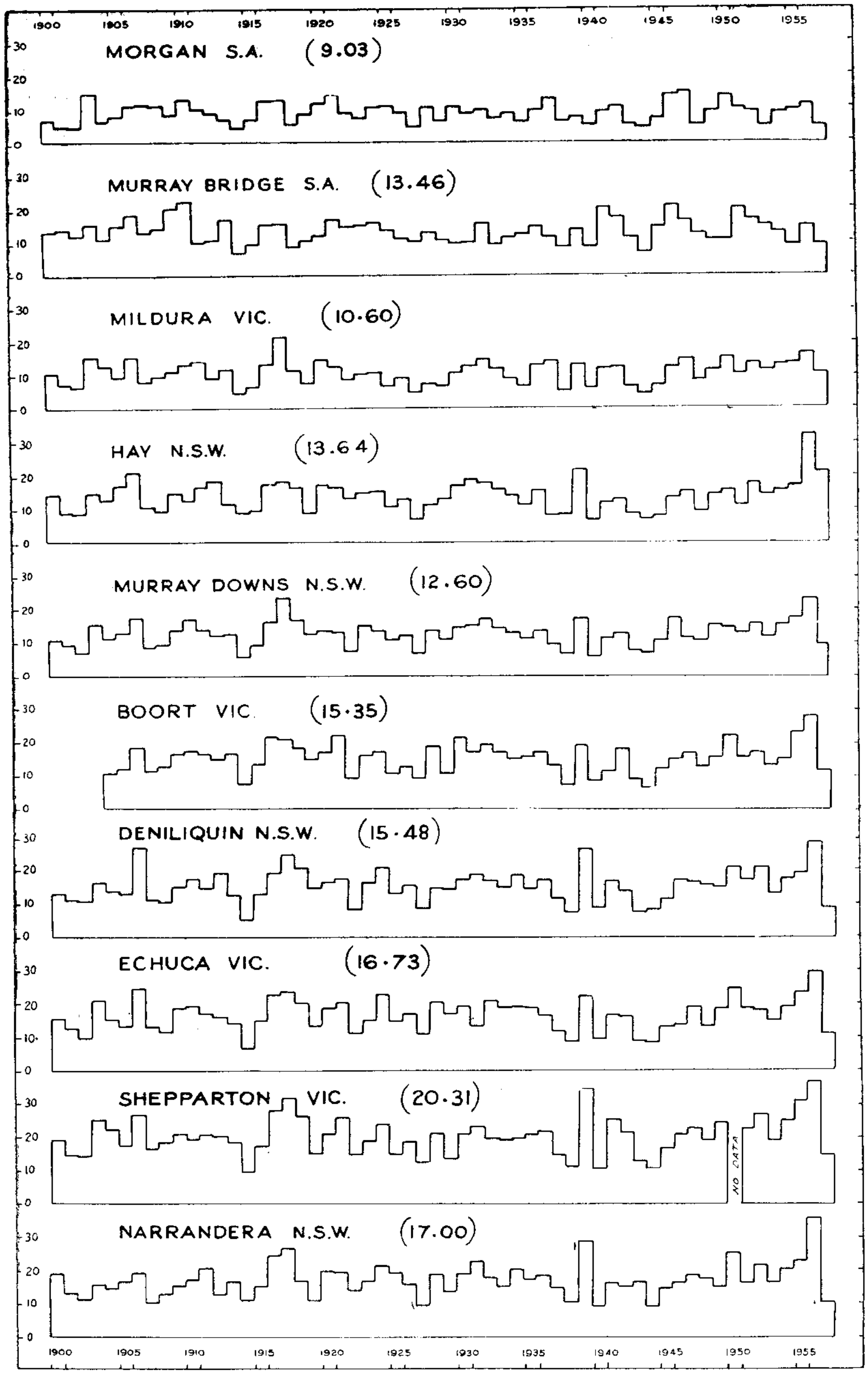

Fig. 3. Annual Rainfalls Recorded at Selected Stations in Southern Murray Basin. Average Annual Rainfalls shown in Brackets

Whilst it exhibits few of the monsoonal characteristics of northern Australia, the southern Murray Basis provides a good cross-section of the climatic difficulties which have beset settlement of the inland plains of southern Australia during the past 100 years. It is true that, when judged by World standards, much of the region experiences a variability of rainfall equal to or below the "World standard value" for regions of comparable average total rainfalls.[15] Only the northern and north-western sectors have variability values above comparable rainfall zones in the rest of the World. However, bearing in mind the moisture needs of the kinds of farming made possible during average or above average years, it will be seen that the southern Murray Basin's interior plains and Mallee country are zones of relatively high climatic uncertainty. Most of this country lies astride of the boundary between the semi-arid and sub-humid climates and rainfall tends to fluctuate around a critical level for arable farming. Falls below the average seasonal requirements for successful grain crops are common and, in many areas, these spell significantly reduced yields or crop failures, despite the fact that a gradual shift of wheat growing into drier and less reliable areas was encouraged by considerable changes in wheat growing techniques adapted to lower rainfalls.

Fluctuations of livestock numbers, wool and cereal yields emphasise the variable success achieved by agriculture in the southern Murray Basin and it is not difficult to relate these variations to the pattern of rainfall received in the growing seasons.[16] Rainfall is the most critical element of climate in the region and production levels fluctuate more from climatic influences than from any other cause.[17] In common with zones of similar economic development (if different terrain and temperature) in the western Prairies and

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[15] See map in *The Australian Environment* (Melbourne: Commonwealth Scientific and Industrial Research Organisation, 1950), p. 29.

[16] A number of studies have been made of variations in wheat yields in various parts of Australia including:

E. A. Cornish, "Yield Trends in the Wheat Belt of South Australia During 1896-1941", *Journal of Scientific Research,* Vol. 2 (1949), pp. 83-137.

Edgars Dunsdorfs, *The Australian Wheat-Growing Industry* 1788-1948 (Melbourne: Melbourne University Press, 1950), pp. 381-401.

J. N. Lewis and B. Dawson, "Reliability of Wheat Yields, Variations in New South Wales by Shires", *Quarterly Review of Agricultural Economics,* Vol. 1, No. 2 (April, 1948), pp. 12-13 and Vol. 1, No. 4 (October, 1948), p. 2 (map on opposite page).

J. Andrews, "The Present Situation in the Wheat-Growing Industry in South-Eastern Australia", *Economic Geography,* Vol. XII, No. 2 April, 1936), pp. 109-135.

Studies which show trends in stock numbers in parts of the southern Murray Basin include:

N. C. W. Beadle, *The Vegetation and Pastures of Western New South Wales with Special Reference to Soil Erosion* (Sydney: Government Printer, 1948), pp. 83-91.

R. S. G. Rutherford, "Fluctuations in the Sheep Population of New South Wales, 1860-1940", *The Economic Record,* Vol. XXIV, No. 46 (June, 1948), pp. 56-71.

[17] The relative importance of rainfall in determining climatic types in Australia has been emphasised by: S. M. Wadham and G. L. Wood, *Land Utilization in Australia* (Melbourne: Melbourne University Press, Revised Edition 1955), p. 41. *Also*: B. Haurwitz and J. M. Austin, *Climatology,* (New York: McGraw-Hill Book Co., 1944), p. 366.

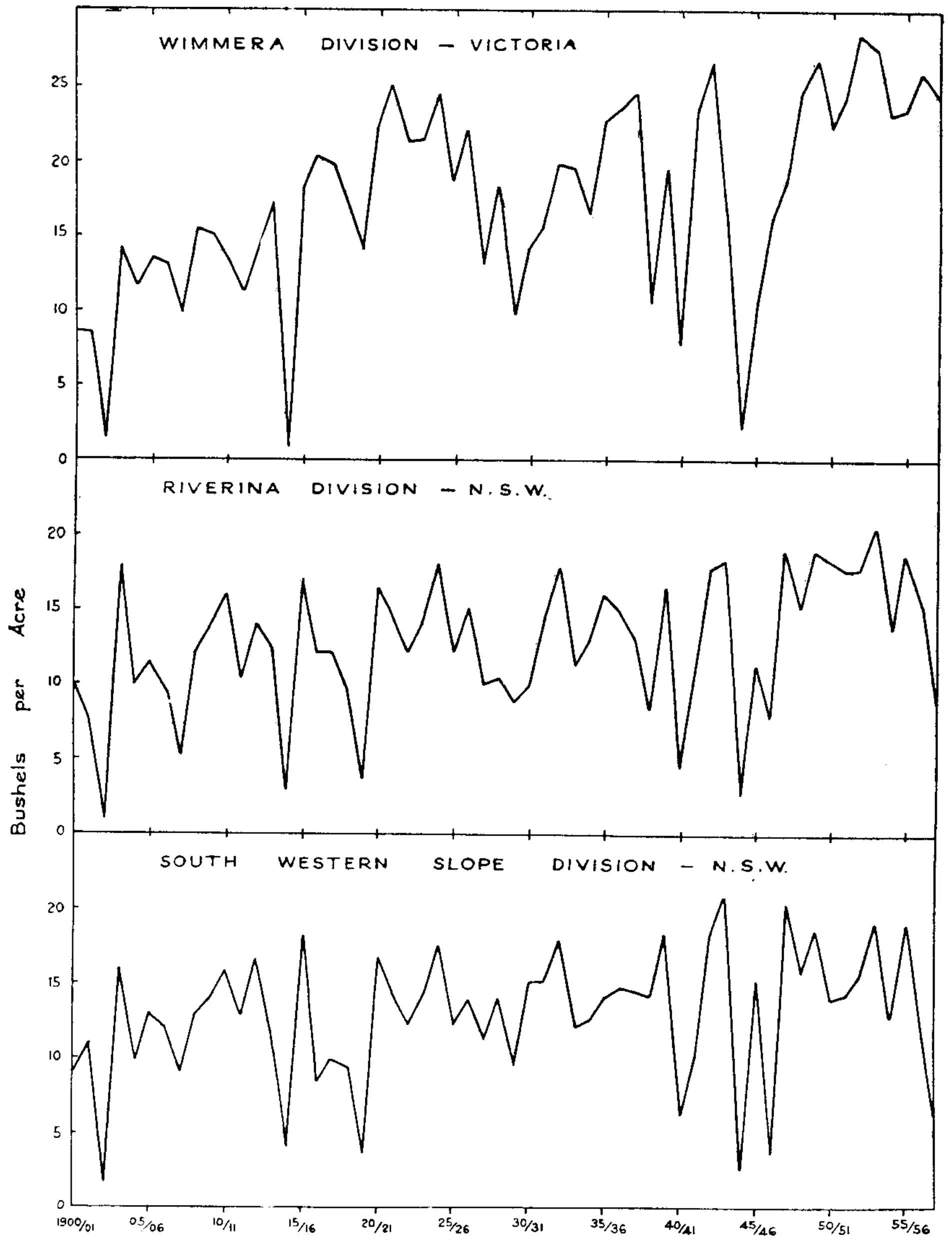

Fig. 4. Trends in Wheat (Grain) Yields for Selected Statistical Divisions of Southern Murray Basin

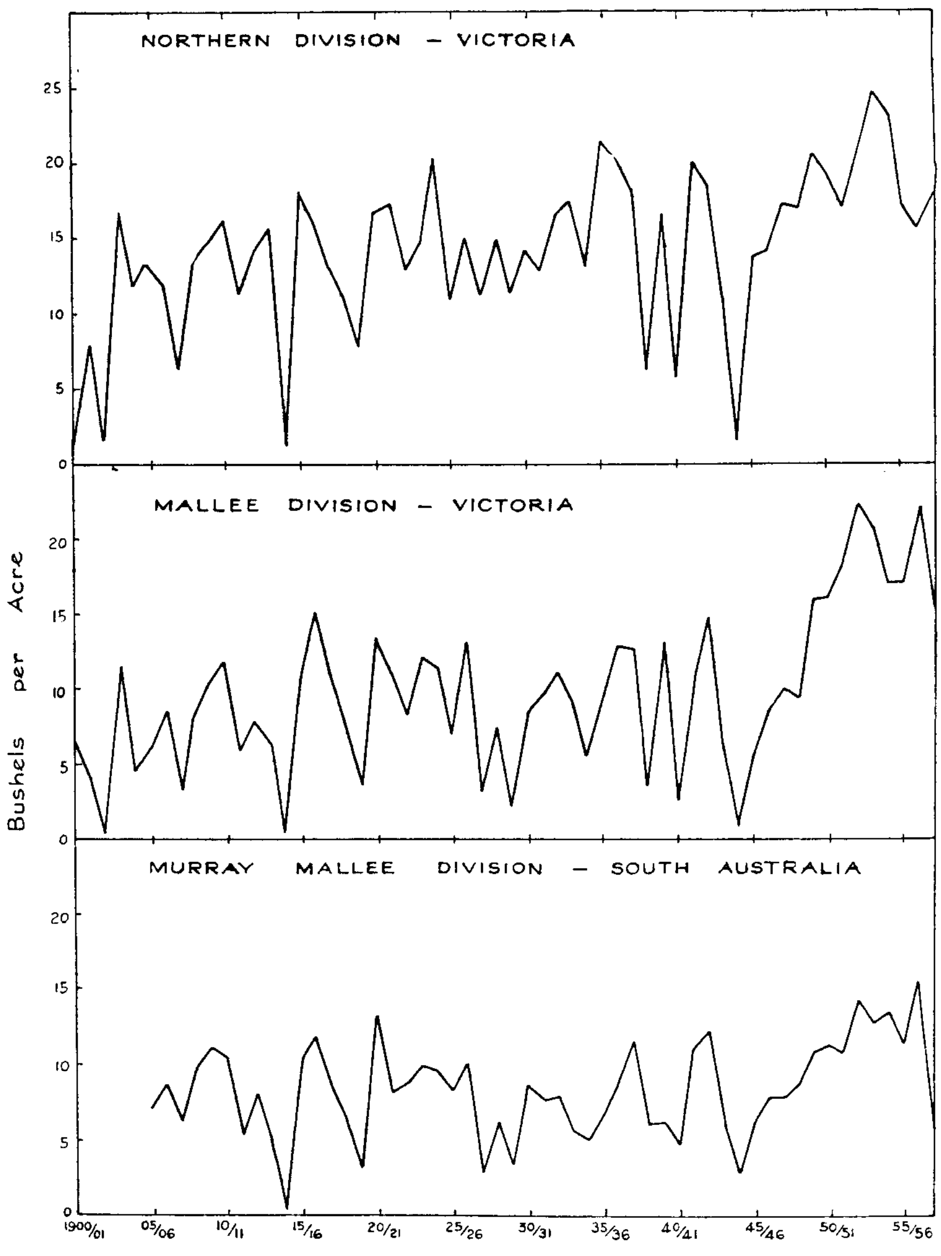

Fig. 5. Trends in Wheat (Grain) Yields for Selected Statistical Divisions of Southern Murray Basin

Great Plains of the United States,[18] the Mallee and riverine plains of the southern Murray Basin face vital elements of rainfall uncertainty which can be inferred from a close inspection of the graphs shown in Figures 3 to 8.[19] These include:

(i) Unpredictable fluctuations in rainfalls.

(ii) A highly variable and unpredictable geographic spread of below average rainfalls and accompanying low crop yields and stock losses.

(iii) A tendency for seasons which are "good" or "poor" for rural production to bunch into sequences of irregular length.

All of these conditions have proved highly disturbing to the economies of the riverine plains and Mallee and this is very similar, if not identical to, the situation in the semi-arid country of the central and western United States as described by Thornthwaite,[20] Schultz,[21] Clawson,[22] and many other American writers. The environmental problem of the semi-arid zone of the United States has been pinpointed in the following terms:—

> "In a desert, you know what to expect of the climate and plan accordingly. The same is true of the humid regions. Men have been badly fooled by the semi-arid regions because they are sometimes humid, sometimes arid, and sometimes a cross between the two. Yet it is possible to make allowances for this too, once the climate is understood."[23]

From his study of droughts in Australia, Foley[24] has concluded:

> ". . . The method of tracing the fluctuations in rainfall in relation to the 'normal' month by month demonstrates that the climate in all parts of the Commonwealth is subject to large and irregular variations in rainfall and there is no reason to doubt that the great fluctuations in rainfall, especially in inland areas, will be repeated in the future. It may possibly be argued that the worst conditions experienced in the last 100 years do not represent the worst conditions ever likely to be experienced."

> ". . . The rapid expansion of primary industries in Australia in the last fifty years has greatly increased the vulnerability of the economic position of the country to drought. Had the 1895-1903 drought occurred in 1945-1953 it may be argued that its effects would have been very much more far reaching.

> ". . . The incidence of droughts and dry periods shows no regular rhythm either as regards time of onset, duration, or extent of territory affected. This indicates that there is little or no prospect of successfully forecasting drought from an assumed occurrence of rainfall cycles.

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[18] See for example Report of the Great Plains Committee, *op. cit.*

[19] Rainfall data from figures published by the Commonwealth Meteorological Bureau. Agricultural statistics from: *Statistical Register of New South Wales*, and *Victoria Year Book*. Also, unpublished statistics obtained from the Sydney office of the Commonwealth Bureau of Census and Statistics.

[20] C. W. Thornthwaite, "Climate and Settlement in the Great Plains", *Climate and Man*, USDA, Yearbook of Agriculture, 1941 (Washington: Government Printing Office, 1941), pp. 177-187.

[21] T. W. Schultz, *Agriculture in an Unstable Economy* (New York: McGraw-Hill Book Co., 1945), pp. 39-41.

[22] Marion Clawson, *op. cit.*

[23] Thornthwaite, *op. cit.* p. 177.

[24] J. C. Foley, *Droughts in Australia. Review of Records from Earliest Years of Settlement to* 1955 (Melbourne: Commonwealth Bureau of Meteorology, Bulletin No. 43, 1957), p. 223.

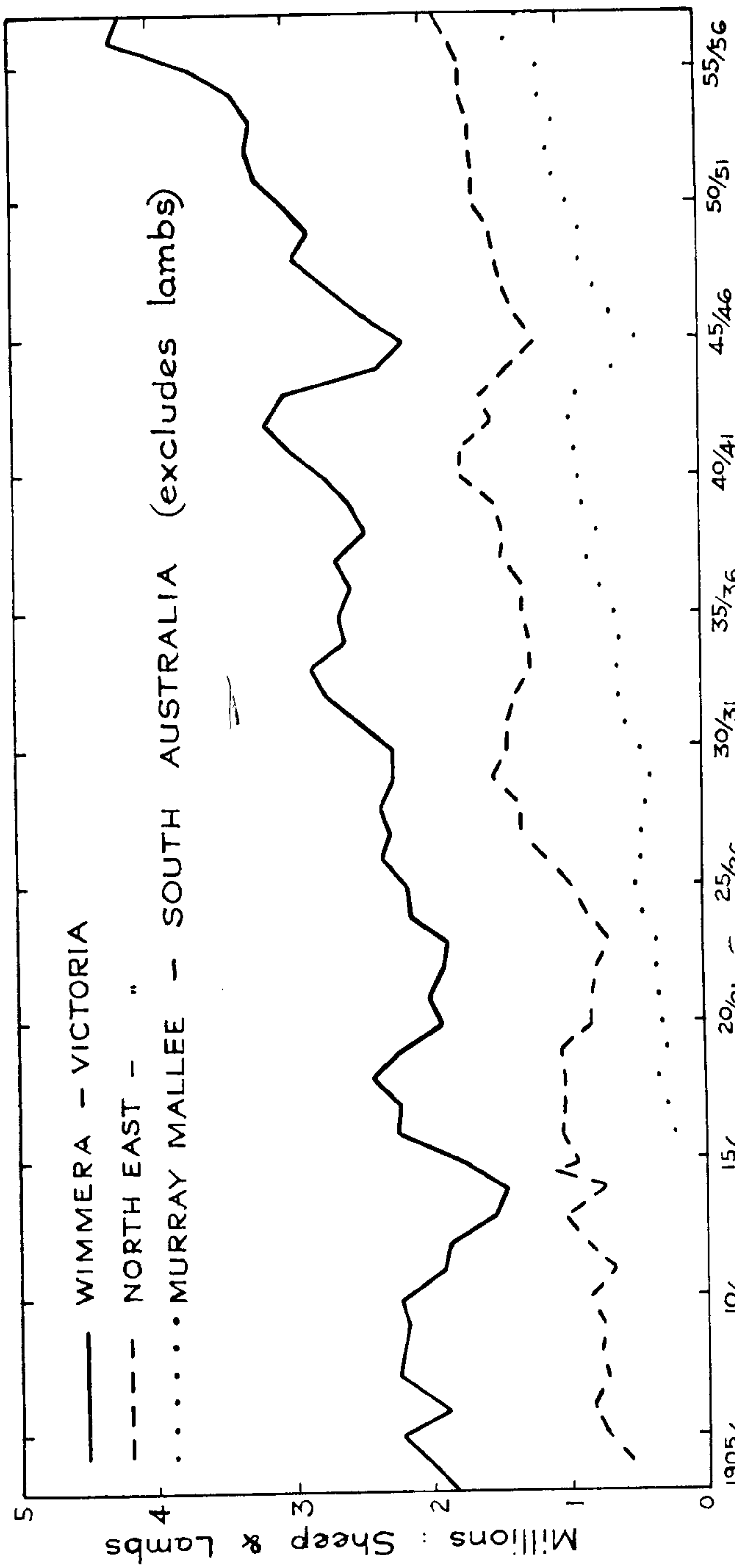

Fig. 6. Trends in Sheep Numbers in Selected Statistical Divisions of Southern Murray Basin

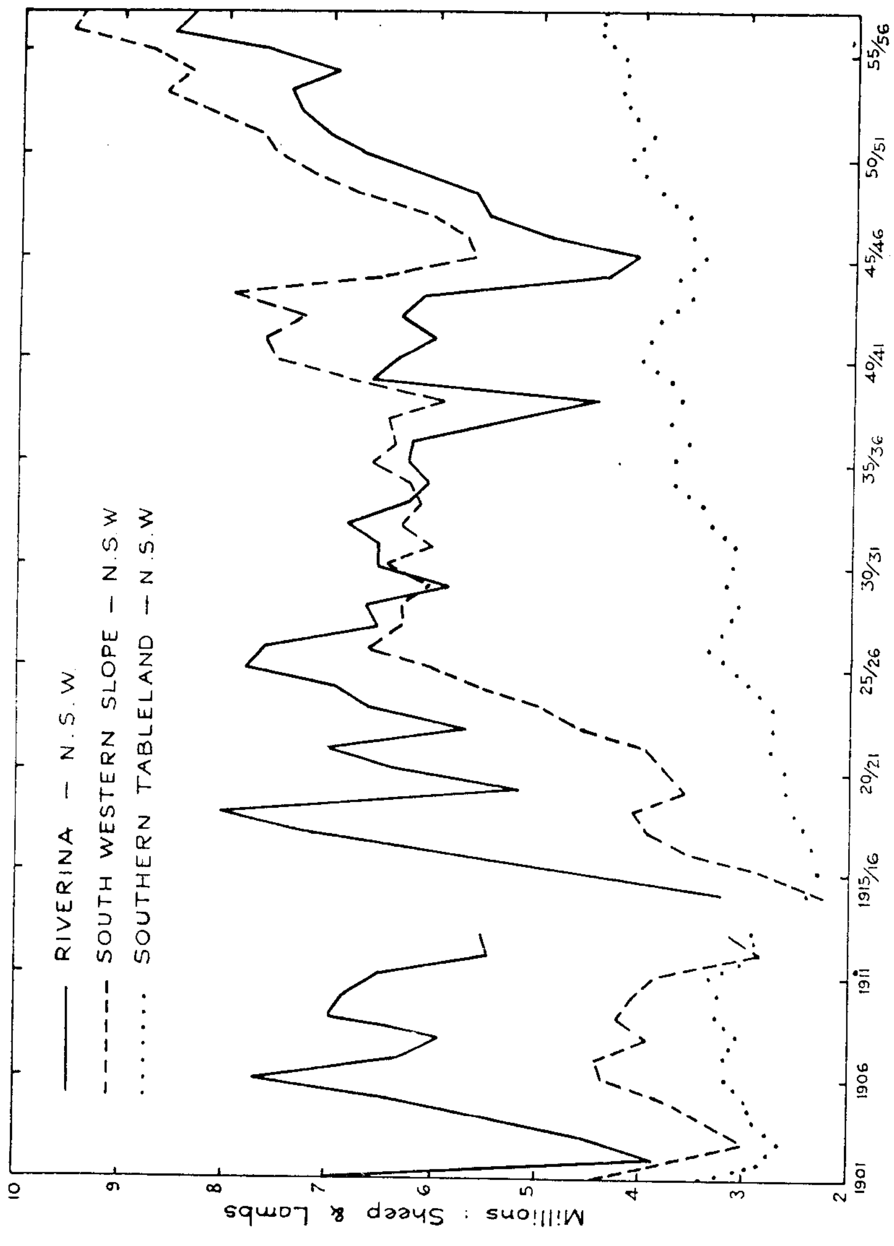

Fig. 7. Trends in Sheep Numbers in Selected Statistical Divisions of Southern Murray Basin

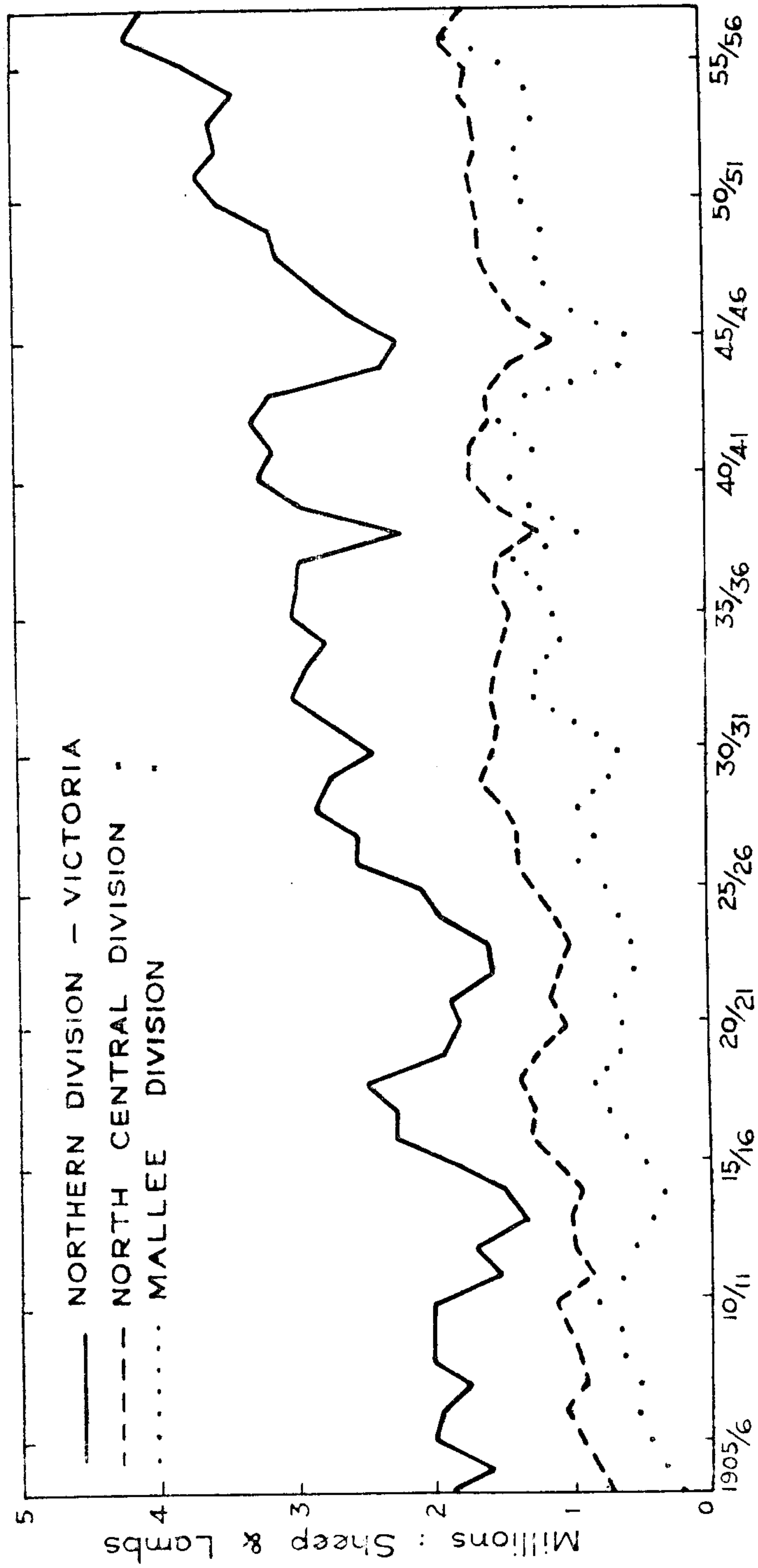

Fig. 8. Trends in Sheep Numbers in Selected Statistical Divisions of Southern Murray Basin

This then is the setting in which agriculture has to develop in the dry sub-humid and semi-arid lands of the southern Murray Basin—an environment which poses a highly unpredictable pattern of future production levels and farm incomes, especially difficult for producers operating with limited reserves and relatively inflexible farm capital structures.

A zone of particular climatic uncertainty in the southern Murray Basin lies on the dry side of the inland margin for arable farming under rainfall (see Fig. 9). This embraces the western Riverina Division and lower Western Division of New South Wales, the north-western parts of the Northern and Mallee Divisions of Victoria and much of the Murray Mallee Division of South Australia (see Fig. 2). In this belt, the pattern of rainfall produces an uncertain base for attempts to extend both the arable farming and more intensive (fat lamb) types of livestock production into the dry sub-humid and semi-arid areas, consequently these have met with serious setbacks and numerous cases of farm abandonment. Tremendous stock losses have also been suffered periodically in the Merino wool industry. Adjustments already made to farm practices and resource allocation within the zones of climatic uncertainty will ensure a reduction of the impact of poor seasons in the future.[25] However, whilst new crop varieties, soil moisture conservation, the introduction of better fodder crops and larger farms, will mean a lessening of the impact of "spotty" droughts, there is still grave doubt about the outcome of more serious moisture deficiencies.

We have witnessed a dramatic "change of heart" in the semi-arid and dry sub-humid areas, but what does the future hold? The trends of wheat yields and sheep numbers shown in Figures 4 to 8 tell a story of the remarkable change in fortunes which occurred during the twenty years prior to 1958. For example, runs of poor seasons to 1945 swelled the ranks of those who claimed that the "Victorian Mallee should be abandoned for crop farming." By contrast, between 1946 and 1956 better cultural techniques and a long period of good seasons produced many excellent harvests and the Mallee became Victoria's premier wheat area.[26]

It is apparent that the long swings of seasonal conditions have distracted attention from the problem of developing a pattern of settlement in the southern Murray Basin adapted to the long-run dictates of climatic uncertainty. The run of good years after 1946 encouraged a build-up of stock numbers with production geared more and more to cater for the profitable wool and lamb trade. There is no doubt that the stock industry in the semi-arid areas became progressively more vulnerable to a severe drought because many farms became "overstocked" and early autumn rains year after year encouraged a trend in many areas towards earlier lambing with an increasing dependence on an uncertain season as measured by long-term trends.

[25] Modified agricultural techniques of wheat farming have played a key role in allowing the "safe" limit for wheat to be extended inland over the years. See: *New South Wales Yearbook,* 1905, 1912, 1923 (Frontispiece map). A. R. Callaghan and A. J. Millington, *The Wheat Industry in Australia* (Sydney: Angus and Robertson, 1956), pp. 113 *et seq.,* Dunsdorfs, *op. cit.,* Part I.

[26] *Final Report of the State Development Committee on the Development of Western and North-Western Victoria* (Melbourne: Government Printer, 1955), p. 15.

5. COMBATING PRODUCTION UNCERTAINTY

The demands of the semi-arid climatic regimes require modifications to traditional concepts of farm management for profit maximisation and community ties between farms built up by experience in more humid zones.[27] For example, as Heady has pointed out,[28] economic consideration of farm management decisions in the face of production uncertainties must pay attention to the problem of farm survival as "an intermediate end" if not "an ultimate end" of the agricultural firm. "The immediate objective in planning is one of 'staying in the game' in order that profits can be realised over an extended period". However, ". . . entrepreneurial behaviour which seemingly contradicts profit or utility maximization postulates should cause the production economist to examine the decision-making framework with greater precision. The manager's apparent irrationality (his failure to adopt the specialist's recommendations) may actually be a manifestation of his highly rational concern for the long-run standing of his firm." In the context of the present study, the high costs often incurred in the initial stages of an irrigation project must be balanced against expected long-range profits and the value to be placed on the added assurance of farm survival.

In attempting to devise a suitable approach for semi-arid areas, research workers and farmers have been handicapped by the fact that settlement of these zones in countries like the United States and Australia is too recent and conditions have been too varied to permit a reasonable assessment of the physical problems. This has been accentuated by the long swings of seasons, particularly in the case of southern Australia since the mid-thirties. Nevertheless, American research[29] has suggested various ways by which individual farmers or groups of farmers and allied institutions can meet the problems posed for rural production by climatic uncertainties. Recommended techniques which can be adopted by single farms include:

(i) Choosing enterprises with relatively low variability of yields.

(ii) Diversifying enterprises.

(iii) Accumulating cash and fodder reserves.

(iv) Increasing scale of operations (particularly farm size).

(v) Improving the liquidity of the farm capital structure.

(vi) Employing cultural techniques that lessen the impact of climatic uncertainty (such as soil moisture conservation).

(vii) Using irrigation to reduce the reliance on rainfall.

Techniques which require group action include:

(*a*) Provision of credit or insurance schemes by which farmers can budget against uncertainty.

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[27] Starch, *op. cit.* See also, other articles on uncertainty and the Great Plains in issues of same *Journal* for August and November, 1949, August, 1950, and November, 1952. Also: Great Plains Council Publication No. 11, *Proceedings of Research Conference on Risk and Uncertainty in Agriculture,* North Dakota Agric. Exper. Sta. Bull. 400 (August, 1955).

[28] Earl O. Heady, *Economics of Agricultural Production and Resource Use* (New York: Prentice-Hall Inc., 1952), pp. 504-505.

[29] See references listed in footnote 27.

(*b*) Implementing systems of tax concessions.
(*c*) Using systems of variable repayment of loans.
(*d*) Developing group fodder conservation schemes.
(*e*) Promoting water conservation and irrigation schemes.

The techniques for combating uncertainty would probably operate in unison, one reinforcing the other. It has been recognised by many economists that a key objective is to design a system of management or resource allocation which enables a "floor" to be placed under the farm business ensuring an enhanced possibility of farm survival despite setbacks.

It is not proposed to examine the economics of production uncertainty in detail here although it should be pointed out that some of the abovementioned techniques have already been adopted with some success in the southern Murray Basin. Irrigation is the only technique which reduces the farm's dependence on the clouds and it can assist the successful adoption of some of the other techniques now greatly handicapped in regions of uncertain rainfall. This latter point is vital to any consideration of the value of integration as discussed in this paper. A few illustrations will suffice.

Diversification of enterprises is a well-known technique for combating uncertainty in both production and price. However, it is of limited assistance on the production side in many regions of considerable climatic uncertainty because all possible lines of production tend to be geared to the one seasonal rainfall regime and there is a high correlation between the yields.[30] An irrigation project may be introduced on to a dryland farm to provide a "floor" under one enterprise, so reducing its yield variability and the correlation which this bears with the fluctuations in yields of other enterprises. The aim would not necessarily be to displace the dryland enterprises.

Dependent as it is on a fairly marked winter rainfall regime, the interior zone of the southern Murray Basin offers a relatively limited range of production possibilities. Many livestock farmers are restricted to breeding for wool production or sale of stores and have to forgo a profitable fattening enterprise or develop one at considerable risk to immediate and long-range income prospects. We have seen how fat lamb raising in some areas is now geared to an uncertain early autumn production, a trend which has tended to make for greater inflexibility and proneness to serious loss. Where a farmer can develop an irrigation project to provide small but vital feed supplies for use in critical periods, he can greatly enhance the flexibility of his production and ensure that he carries sufficient stock through the periods of lean growth to make the fullest use of pastures (irrigated or not) in the periods of maximum growth. Irrigation offers two broad fields of development here. One most likely to find a place on farms in general is the use of strictly limited quantities of water to extend the winter growing season and improve the overall plane of nutrition in the autumn and spring periods. This means an improvement of the normal pattern of production under rainfall. The other more limited possibility (limited because of the greater water requirements) is the production of irrigated summer feed for "out-of-season" fattening of store lambs, beef cattle, etc.

[30] D. Gale Johnston, *Forward Prices for Agriculture* (Chicago: The University of Chicago Press, 1947), p. 53.

In regions of semi-arid climate it is often quite impossible to grow crops of grain or hays in most years to build-up desirable fodder reserves. The farmer can rely on pricy and uncertain supplies by purchase or he can attempt to develop his own irrigated source for the sake of the insurance it gives and despite high initial costs.

6. SCOPE FOR IRRIGATION

Despite the considerable progress made so far, and the relatively limited water resources available, it seems that there is still scope for much more irrigation in the southern Murray Basin, particularly in view of the considerable additional waters made available by new works on the Goulburn, Murray and Murrumbidgee and the presage of large supplies of water from the Snowy Scheme, which will affect the latter two river systems. There is promise also of considerable expansion of smaller-scale irrigation using unit farm schemes pumping on river frontages or with bores and farm dams.

The potential contribution of irrigation by State sponsored "Areas" or "Districts" to a more stable and flexible agriculture in the region, can be considered under three headings:

1. Some areas do not possess water resources for irrigation development *in situ*. Much of the Mallee country and parts of the riverine plains without large permanent streams might come into this category although, in the absence of detailed hydrological research, the extent of this type of country is unknown. It seems, however, that it is not large in proportion to the size of the region as a whole. In addition, it would be unwise to consider the scope for irrigation merely in terms of the *local* water resources. Even where limitations of water supplies inhibit local irrigation development, serious consideration might be given to schemes of "spatial diversification" to connect the so-called "waterless" areas to irrigable country in systems of integrated land use, since modern transport makes the linkage of even remote areas quite feasible. Also, much more can be done with farm water conservation projects relying on rainfall and farm run-off. The development of economic techniques for sealing storages in porous soils opens up a new vista in this field. The success achieved by small irrigation projects in the semi-arid belt, using water from farm dams, streams or bores, to underwrite the production of limited quantities of high quality feed used in critical seasons demonstrates the scope for greatly expanding irrigation in the future. This is especially the case if a concerted drive were to be made to promote an overall increase in productivity in country now faced with varying feed supplies and periodical checks in the rate of stock growth which are inimical to efficient production even on a relatively extensive basis.

2. Sufficient water for "intensive" irrigation along traditional lines could be brought to well-drained soils to permit the development of compact closer settlements producing "exotic" products made possible by a greatly altered micro-climatic regime. The dairying and fruit settlements and also the intensive fat lamb and rice-fat lamb farms are examples of this. However, even if all the presently unused and likely future additional water supplies of the southern Murray Basin were employed in this way, only a relatively small area would benefit directly. To this disadvantage we can add the fact that,

KEY TO IRRIGATION PROJECTS SHOWN ON FIG. 9

(Each group listed in order of location downstream)

1. MURRUMBIDGEE RIVERINE PLAIN PROJECTS (N.S.W.)

   Yanco, Mirrool, Benerembah, Tabbita, Wah Wah, Hay and Lowbidgee.

2. MURRAY RIVERINE PLAIN PROJECTS (N.S.W.)

   Berriquin, Denimein, Deniboota, Wakool and Tullakool. Map also shows Bama, Bringan, Glenview, and Bungunyah-Koraleigh along Murray.

3. MURRAY RIVERINE PLAIN PROJECT (VICTORIA)

   Murray Valley.

4. EASTERN GOULBURN RIVERINE PLAIN PROJECTS (VICTORIA)

   Katandra, North Shepparton, Shepparton, South Shepparton, Rodney, Tongala-Stanhope, Deakin and Rochester. (Campaspe Project on Campaspe River also shown.)

5. WESTERN GOULBURN RIVERINE PLAIN PROJECTS (VICTORIA)

   Dingee, Calivil, Boort, and Tragowel Plains.

6. TORRUMBARRY RIVERINE PLAIN PROJECTS (VICTORIA) FROM MURRAY

   Cohuna, Kerang, Koondrook, Third Lake, Mystic Park, Tresco, Fish Point and Swan Hill. Map also shows Nyah supplied separately from Murray.

7. MALLEE-MURRAY PROJECTS

   Robinvale, Red Cliffs, Mildura and Merbein (Victoria). Curlwaa and Coomealla (N.S.W.). Map also shows Pomona (Darling River in N.S.W.), Chaffey, Renmark, Lyrup, Berri, Cobdolga, Loxton, Sherwood, Media, Pyap, Moorook, Kingston, Waikerie, and Cadell (South Australia).

8. RECLAIMED SWAMPS LOWER MURRAY (SOUTH AUSTRALIA)

   Cowirra, Baseby, Neeta, Wall, Pompoota, Mypolonga, Murray Bridge, Burdett, Long Flat, Swan Port, River Glen, Monteith, Woods Point and Jervois.

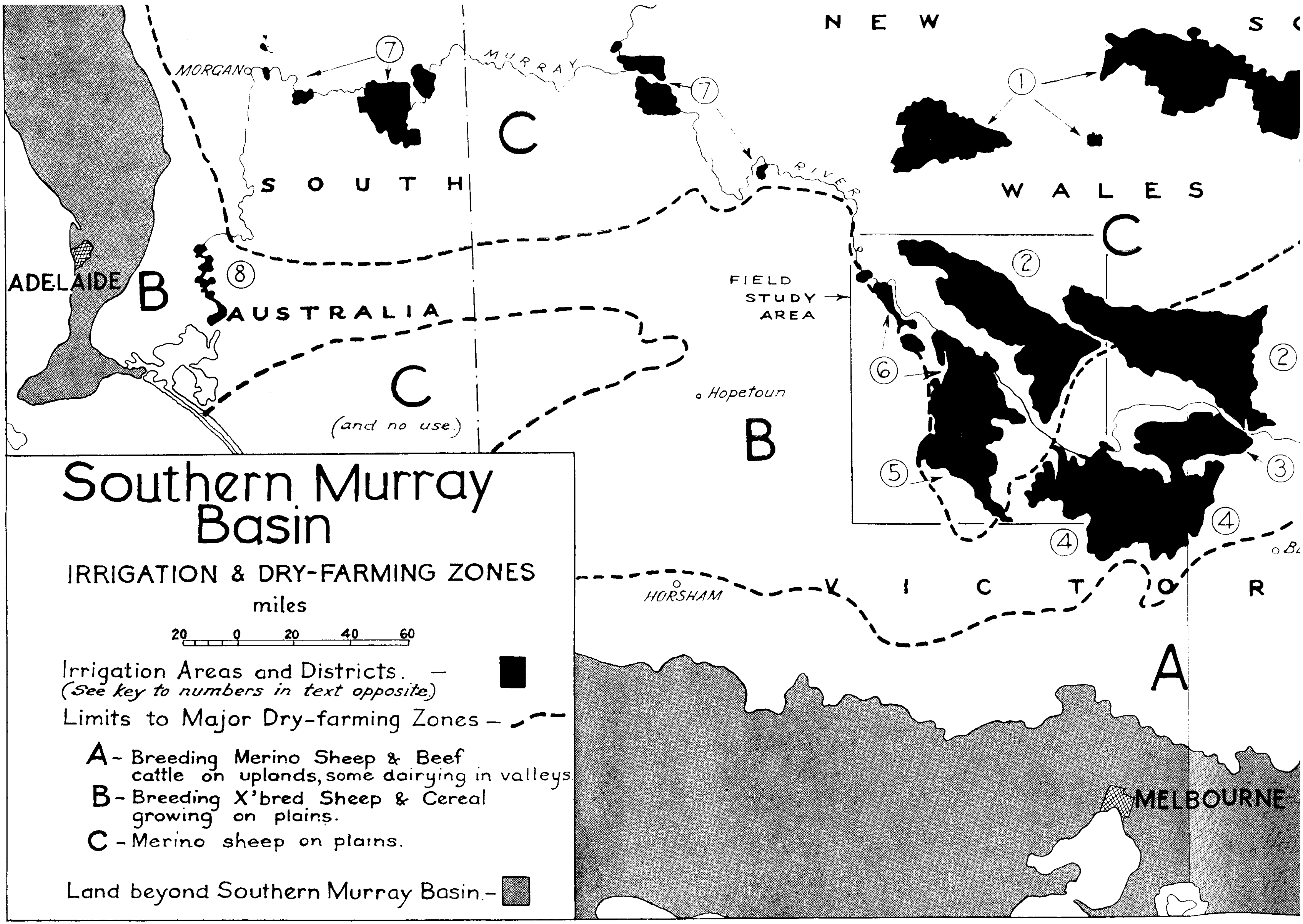

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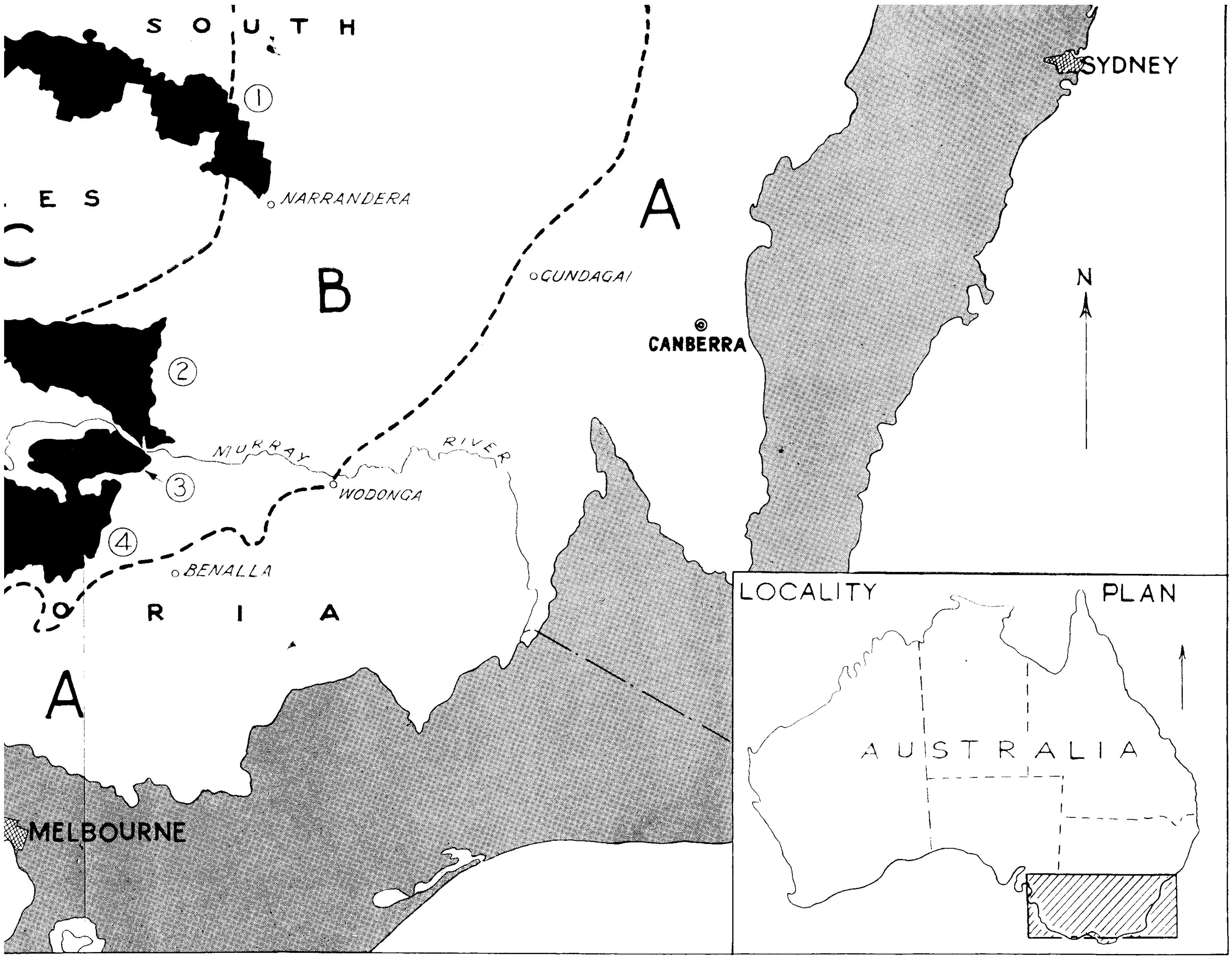
Fig. 9. Community Irrigation Projects and Dry-Farming Zones of S



and Dry-Farming Zones of Southern Murray Basin

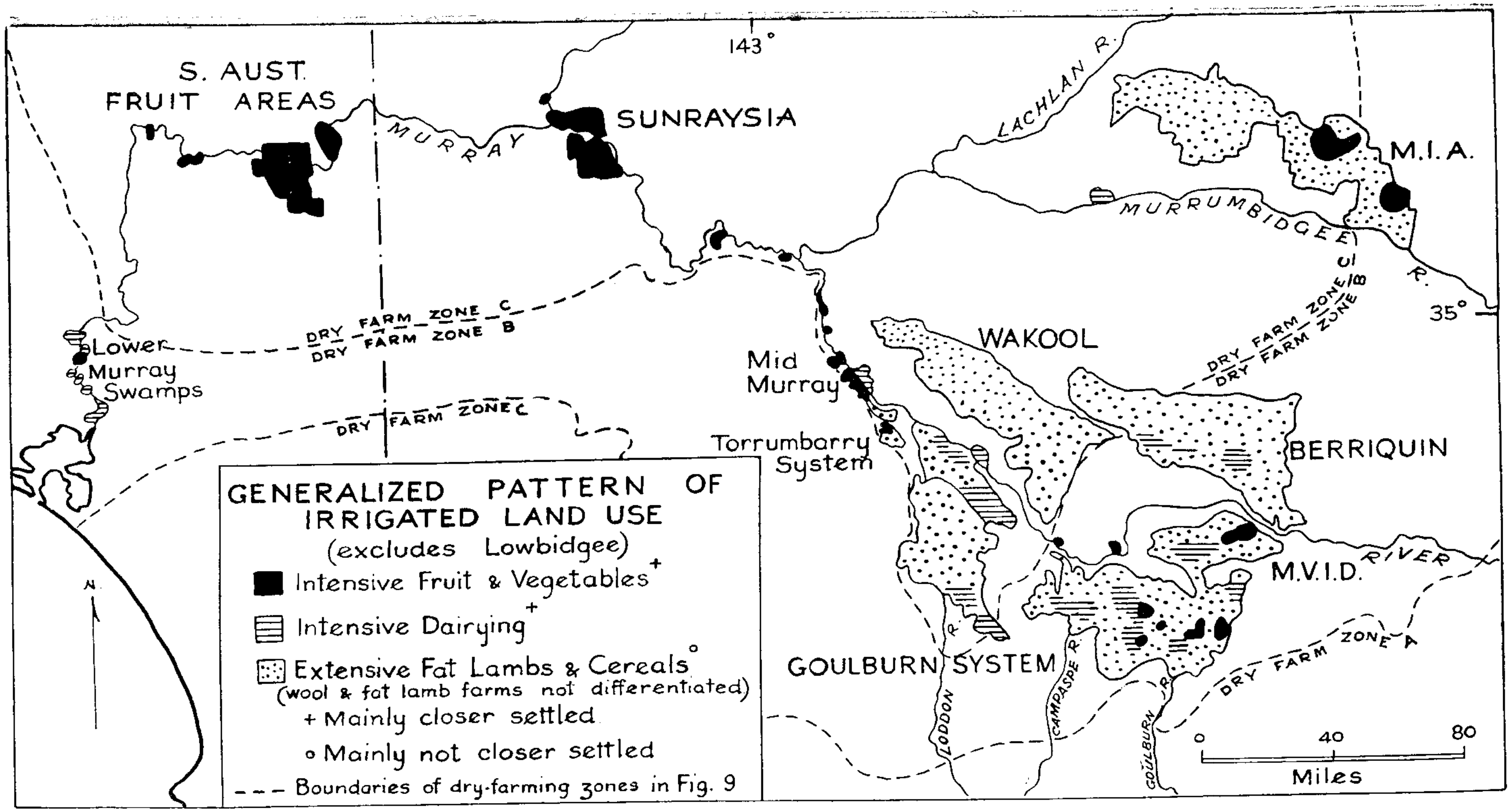


Fig. 10. Generalised Patterns of Land Use within Community Irrigation Areas and Districts of the Riverine Plains and Mallee lands of Southern Murray Basin

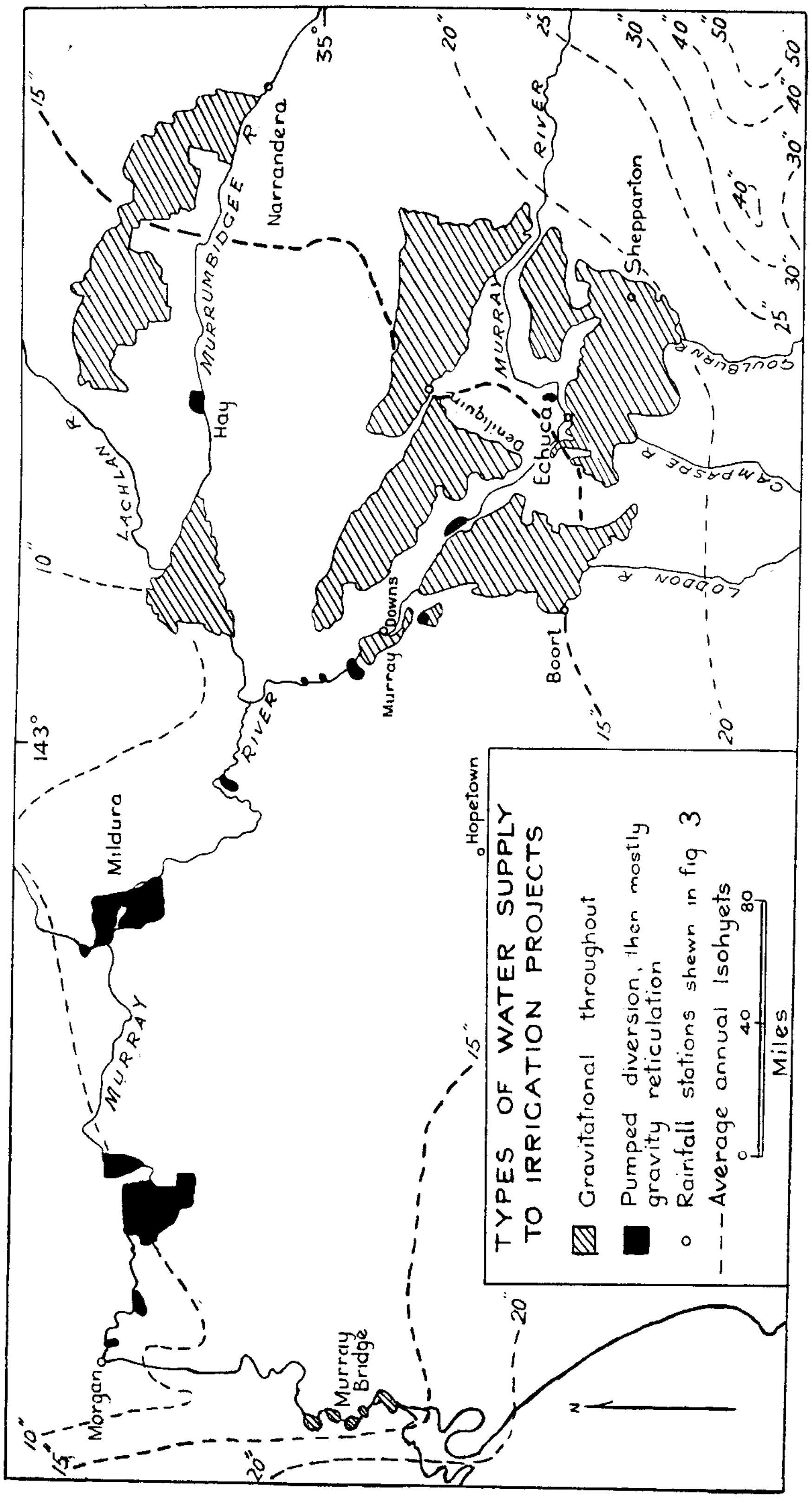


Fig. 11. Types of Water Supply to Community Irrigation Projects and Isohyets in Southern Murray Basin

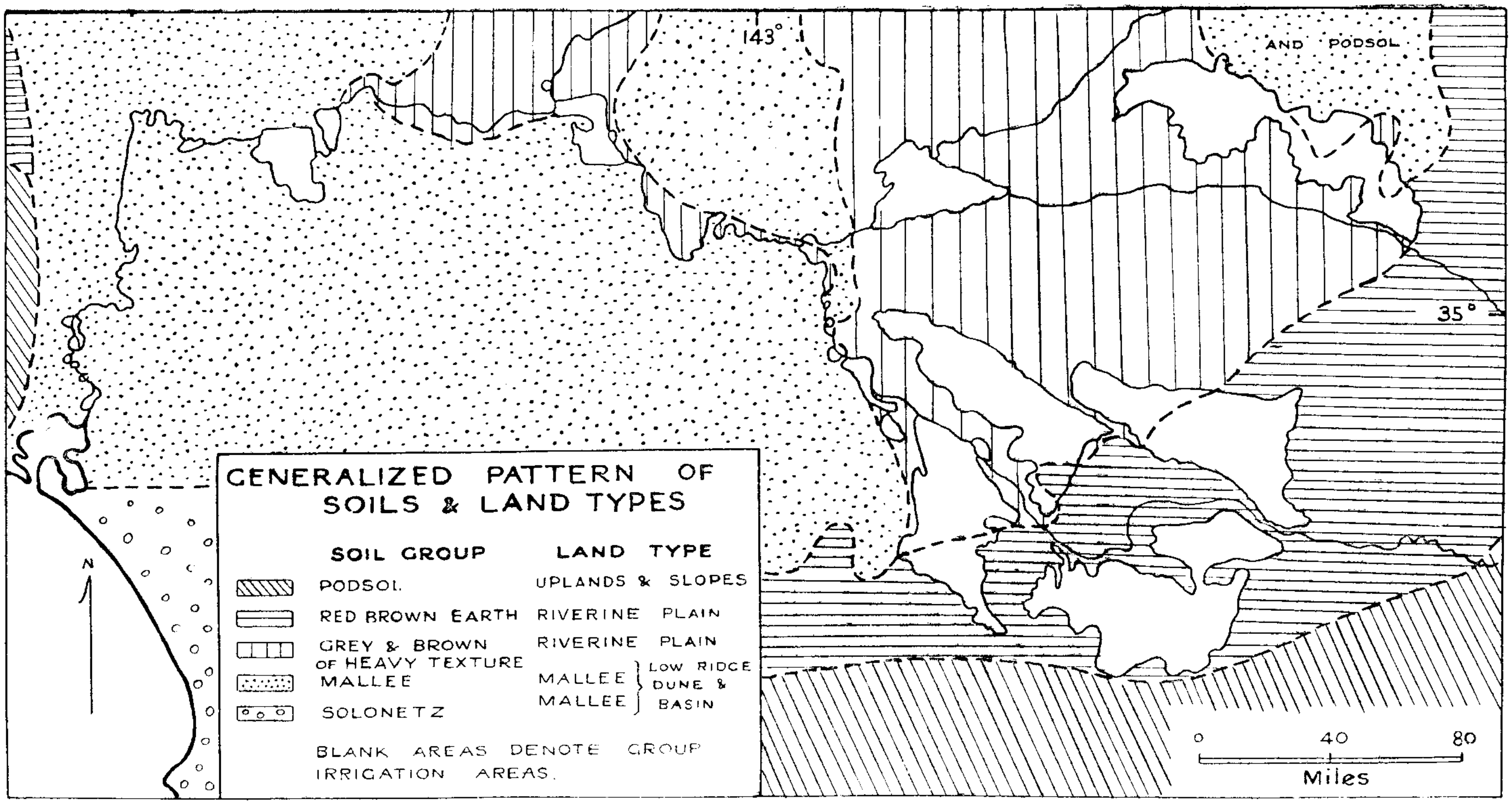


Fig. 12. Generalised Soil and Land Types in Southern Murray Basin in relation to Irrigation Projects
(Some peripheral uplands excluded)

in the foreseeable future, some of the possible products (notably dairy and fruit) of this type of development would be handicapped by adverse marketing conditions. The present economic outlook would dictate caution in the promotion of intensive projects for traditional products, although the possibilities of using irrigation for the export fat lamb trade and perhaps beef production are still quite attractive.

3. A third type of development involves some system of "partial" irrigation in which there is a direct link between irrigated and dryland farming as a primary aim of the project. Traditionally, this type of investment has been identified with the scattered system of water distribution now in vogue in the southern Riverina and many of the districts of northern Victoria. There is no doubt that, having regard to the limited supplies of water available for irrigation in Australia, and the considerable losses of water sustained in scattered irrigation systems, it might be undesirable to foster a large-scale expansion of similar schemes in new areas. However, as mentioned earlier in this article, there seems no reason why intensive irrigation in compact areas, with lower water losses and on better soils, could not be integrated with dryland areas to achieve just the same interaction between the two as is obtained in the existing "partial" irrigation districts, but ensuring higher efficiencies of water distribution and better location of irrigation on well-drained soils close to diversion points which are capable of a diverse range of land uses. Any economic assessment of the merit of using water in a system of integration (whether this involves compact irrigation with "spatial diversification" or even scattered irrigation along traditional lines) must necessarily pay cognisance to the abovementioned possibility, that it might facilitate the introduction of a number of techniques for combating production uncertainty over wide areas (*i.e.*, reducing yield variability, and allowing enterprise diversification, more flexible production patterns and fodder conservation). These advantages would have to be matched against any disadvantages of either scheme.

7. THE CONCEPT OF INTEGRATION

The notion of a better integration between irrigated land use and dryland use forms part of the theories on more efficient water development. It is presented as a modification of traditional approaches to irrigation farming, although some systems of integration embrace some of the techniques already in vogue, particularly in Australia. In its broadest setting, the concept of integration may be viewed as part of the general body of theory advanced by geographers, economists and the like on problems of achieving a more rational development of land resources. Some have recommended radical changes in the current types of land settlement and land ownership patterns to achieve a better distribution of land types within the boundaries of individual farms, having regard to soil and climatic considerations. The growth of integration between irrigated and unirrigated land may ultimately come to this, but in the short-run, it implies a better co-ordination of the economies of farming on the two land types and, in new irrigation schemes, the development of farms with irrigated and unirrigated land instead of only the former.

Referring to irrigation development in the eleven western States of the United States to 1949, Selby has stated:

"About one-half of the half-million farms in the West are irrigated in whole or in part . . Irrigation bears an important relation to the western livestock industry. More than two-thirds of the entire irrigated acreage is used for producing feed crops and pasture. Dairying is the principal type of livestock production on the irrigated lands, but a large part of the irrigated crops and pasture is used for beef cattle and sheep production. Nearly three-fourths of the total land area in the West is range land, used chiefly for grazing beef cattle and sheep. The West has always produced an important surplus of beef cattle and sheep to supply the needs of the rest of the country. For the past three decades, however, production of range livestock has been declining, as a result of declining productivity of the range. Increasing production of irrigated feed crops and pastures has offset this declining range production to a considerable extent.

"Irrigated feed production also makes possible the fattening and finishing of more beef cattle and sheep in the West to supply the expanding western markets."[31]

Over the last two decades, American agricultural economists[32] have undertaken an appraisal of integration in selected areas of their country (particularly the Missouri Basin) and some have given much weight to these developments when considering projects for the future. Many existing irrigation scheme in the United States, and proposals for further expansion are located within semi-arid grazing and cereal growing areas of "high plains" experiencing great climatic uncertainty. In view of this, and as a reaction to the economic and physical hardships that arose in the wake of past irrigation schemes which extended the frontiers of small-scale family farming in the semi-arid and arid zones, questions have arisen from time to time about the desirability of encouraging exchanges between irrigated and unirrigated land uses for their mutual benefit. Advocates of this tie have stressed that it should receive more serious thought than it received in the past when many promoters of irrigation projects were seemingly obsessed with the desire to bring to the semi-arid lands "unadapted culture patterns from humid areas"; economies that "have plagued the semi-arid areas since earliest settlement."[33]

Some agricultural economists have come to regard integrated irrigation farming as a possible answer to the deficiencies of diversification in regions of semi-arid and highly variable climate. Thus we have the concept of integration as a form of "area or spatial diversification" to replace the more traditional concept of enterprise diversification within single farm units. Discussing the need for modifications to the type of farming in the Great Plains of the United States, Starch has said:

". . . The physical resources as well as the economic structure must at all times be 'cushioned' to meet anticipated variations in conditions.

[31] H. E. Selby, "The Importance of Irrigation in the Economy of the West", *Journal of Farm Economics,* Vol. XXXI, No. 4, Part 2 (November, 1949), pp. 955-957.

[32] Although the concept of integration has been developed most by American writers, it is referred to elsewhere (other than in Australia). For example, see: Harold H. Mann, "The Economic Results and Possibilities of Irrigation", *Indian Journal of Agricultural Economics,* Vol. XIII, No. 2 (April-June, 1958), pp. 1-6.

[33] Roy Huffman, *Irrigation Development and Public Water Policy* (New York: The Ronald Press Co., 1953), Chapter 9, pp. 122-148. This discusses the possibilities and limitations of integration.

". . . The keystone of an economy based on variations would be flexibility. Or to use a catchphrase, it would be an ability to 'roll up' and 'unroll' much after the manner of some plants and seeds which have structural provision for meeting unfavourable conditions in order that they may later take advantage of suitable growing conditions. This flexibility would necessarily be such that a farm or ranch operator might reach out rather quickly to take advantage of good grass and good farm conditions. He needs a combination of enterprises so that he can emphasize at least one such enterprise which he knows will respond to the immediate weather condition.

". . . No doubt it will be necessary to further recast some concepts that apply in areas of more or less consistent weather, and one of the concepts that may undergo drastic revision is that of diversification. On the Great Plains, it is not possible to diversify within the limits of a given farm unit which may lie on one or two sections of upland. The farm unit may be located on benchland which is admirably suited to wheat production, and since wheat is better adapted to an arid climate than any other cultivated crop, wheat is no doubt the best crop for that farm. If we undertake to revise a farm organization by incorporating alfalfa and oats, we may find that the net income for that farm is materially reduced and nothing will have been added to the stability of that farm unit for the reason that it is the low productivity years which set up the strain in farm organization. It has been the experience of farm operators that wheat is the last crop to fail, with the possible exception of native grass.

"Diversification by areas, however, as over against diversification by specific farm units may be a concept which will apply under semi-arid conditions. For example, if you have some irrigated land within an area covering several townships, also some good wheat land and some grazing land, it is possible to work out a use pattern whereby all of these types of resources can be woven together into stable operating units. Under the concept of area diversification, the farm headquarters would be located within the irrigated area, and assuming that the feed crops were grown on irrigated land, we might also assume that in this modern day the same operator could economically grow wheat upon high class wheat land not too far distant. He could move his rubber tired machinery several miles and carry on the field operations with very little loss in efficiency. His livestock would run on the grazing reservation which might be near his home or some distance away. This grazing reserve would be handled co-operatively, and the cattle would be taken care of by the Association during the grazing season. Thus, by taking advantage of different types of resources over a larger area, the farm operations may be well diversified, with some alfalfa for a feed base, with some wheat grown according to good Soil Conservation methods, and with livestock on the grazing reserve.

"Diversification as a principle is as sound on the Plains as anywhere. However, the application of it requires definite modification. Whereas this concept may be somewhat difficult to envisage, yet it is entirely possible that a plan of diversification covering as much as an entire county could be worked out."[34]

It is considered that the concept of "spatial diversification" merits closer study in Australia despite the dissimilarities between the climate of local areas and those of the American Great Plains (see pp. 274-5).

[34] Starch, *op. cit.*, pp. 114-120. A need for more integration between irrigation and dryland farming to achieve the type of "spatial diversification" mentioned by Starch is emphasized by R. R. Renne, in "An Economist's Appraisal of the Missouri River Development Program", *Journal of Farm Economics*, Vol. XXXI, No. 4, Part 2 (November, 1949) p. 1020-1021. For a discussion of problems posed by this kind of development, see M. M. Kelso, "New Directions for Land Economics Research: West", same *Journal*, pp. 1037-1038.

Types of Integration

At the outset, two broad types of integration were listed—"on-farm" integation was distinguished from "off-farm" integration to contrast situations where the irrigated and unirrigated lands are combined within the single farm business from those involving exchanges of products between farms. Various types of integration fall under these two headings.

"On-Farm" Integration

Obvious examples of the integration occur when both irrigated and unirrigated land are included within the resources of the single farm business. These lands might be owned, leased or sharefarmed, but it is their combined area which constitutes the total land resources of the farm. Integration of the "on-farm" variety can take three forms, similar in many respects but worth separating. These are typified by:

(i) A farm with its headquarters and/or most important land unit in an irrigation district which also has unirrigated land outside of the district.

(ii) A farm with its headquarters and/or its most important land unit in unirrigated country which has some land (usually a "feed base") in an irrigation district.

(iii) A property located within a "partial" irrigation district where, as a result of the conditions of water supply and/or physical conditions, only part of the farm is irrigated.

Huffman[35] recognises the first two as the most "direct" systems of integration and he contends that they are a major factor in promoting and maintaining a stable economy. With regard to the third type commonly encountered in partial irrigation areas he says that it is a

> ". . . form of integration which is favoured by landowners in connection with some new irrigation developments. It involves the 'scattered' irrigation pattern as contrasted to the 'solid block' pattern characteristic of existing projects. This proposed system of irrigation development would include a much larger acreage within the distribution system of the project than there would be water available to irrigate. Only a part of each farm unit would be irrigated and the total acreage which could be irrigated would be determined by the water available. Greater water loss in the larger distribution system might result in less total acres irrigated than could be watered under a smaller distribution system.
>
> "Proponents of this . . . type of irrigation pattern point out that it would do the following:
>
> 1. Permit selection of lands best adapted to irrigation.
> 2. Largely eliminate the drainage problem.
> 3. Spread the stabilizing effects of irrigation development over a larger area.
> 4. Encourage a highly diversified type of agriculture.
>
> "Principal objections raised by engineers concern the increased construction costs and the increased loss of water through evaporation and canal seepage on the larger distribution system. For any given irrigation development, *these factors of increased cost and decreased efficiency in the carriage of water should be balanced against the possibilities for greater over-all*

[35] *Irrigation Development and Public Water Policy, op. cit.*, pp. 130-132.

benefits to the area concerned. Certainly this method of development should be thoroughly investigated, particularly for possible use in the Great Plains where potential projects often include a much larger acreage of irrigable land than the available water will cover."[36]

These comments by Huffman can be applied to the "partial" irrigation schemes of the southern Murray, particularly, those of the Riverina. However, additional objections raised to "partial" irrigation in these cases include:

(i) The tendency for land use to become considerably more intensive often on the basis of short-term increases of water supplies (in most cases on "sales water") and not on "water rights" guaranteed over the long term. Because of this, it is claimed that these projects may have failed to achieve greater stability for dryland production which was their original purpose;

(ii) despite the merit of irrigation, farms are still wedded to a limited range of production possibilities based on irrigated winter pastures;

(iii) scattered irrigation has made the implementation of a sound drainage scheme much more difficult, and the trend to more intensive irrigation (especially with summer pastures) places severe strains on a channel system designed to cope with less intensive irrigation of the "winter" type.

Notwithstanding the obvious shortcomings of "partial" irrigation, it is the writer's opinion that the concept may still require closer appraisal in terms of the economic balance sheet suggested by Huffman. Especially where it has encouraged dairying and fat lamb production, "intensive" irrigation in south-eastern Australia, as the alternative to "partial" irrigation, has tended to be used for forms of production possible already in areas of higher rainfall without irrigation. Admittedly, irrigation farms have been able to achieve certain production advantages over their non-irrigated counterparts, but it is still questionable whether these advantages could not be achieved elsewhere just as economically without irrigation by pasture improvement and improved management generally. The higher costs involved in "partial" irrigation might conceivably be warranted in some cases where water is used to assist production which has no other means of achieving the same level of efficiency of resource use. An example of this might be irrigation to assist the production of Merino wool or the fattening of store stock (*e.g.*, beef cattle) in semi-arid regions climatically suited to breeding but not to fattening in most years.

It has been argued by some that irrigation and Merino wool growing do not go together in an efficient way. However, the fact (often used as a substantiating argument) that farmers in the present-day "partial" irrigation districts have drifted out of Merino wool growing into fat lamb raising is not necessarily "an inevitable consequence of irrigation" or the "unsuitability of irrigation to Merino wool growing" but it is, in large measure, the consequence of the supply of sufficient irrigation water to allow a basic dependence on irrigated land, and this is not favourable to Merino wool growing. In northern Victoria, fat lamb production using cross-bred sheep instead of Merino wool growing has been encouraged also by the small farms developed prior to irrigation. In New South Wales, the supply of irrigation water preceded the closer settlement. Had water supplies to each

[36] My italics.

holding been kept at a low level (say, the original level) despite pressure from landholders to the contrary, it is quite possible that Merino wool growing, as well as a much more extensive pattern of farming and a more active integration between dryland and irrigated farming would still persist on a more significant scale in the Riverina. The additional water granted to existing irrigators might then have been given to other farms. However, more extensive development could only be justified from an economic viewpoint if (i) it encouraged a *type* of product economically more attractive than alternative types sponsored by more "intensive" irrigation, and (ii) even with no change of type of product, the net productivity of water was higher than would be the case with more "intensive" uses of water. Much more research is required on the return to water under irrigation before the relative merits of these alternatives can be assessed, but this must be done before firm opinions can be given on the economics of "partial" irrigation versus "intensive" irrigation.

"Off-Farm" Integration

Integration may involve situations where there is not any joint control of both irrigated and unirrigated land uses but where dryland and irrigated economies benefit from one another by exchanges of commodities used as factors of production on recipient farms and/or where the juxtaposition of the two economies makes for more balanced and mature socio-economic development. In these respects, the following types of "off-farm" integration might be distinguished:

(i) Huffman has described the "stabilizing influence exerted in an area by a body of irrigated land even though the units involving actual combination may be few or non-existent. The irrigated area does provide a source of hay for use by the operators in the surrounding range area. Feed grains may move both ways, depending on the circumstances. In drought periods, dryland operators may turn to the irrigated areas for feed grains as well as hay. During periods of favourable weather conditions, those engaged in livestock fattening programmes on irrigated farms may find the surrounding dryland areas to be their cheapest and most convenient source of feed grains".[37]

This type of integration tends to develop in livestock farming areas and is found in many parts of the southern Murray Basin. It is much less recognisable and very much more difficult to measure than the other types mentioned above.

> "The looseness of this type of integration should be emphasized. *The closer the integration can be made between irrigated and grazing land, the less likely it is to get out of balance during periods of drought or above-average precipitation.* Operators in dryland areas usually produce sufficient feed on their own units during periods of high precipitation and do not buy feed from the operators on irrigated land. The operators of irrigated land are forced to grow other crops when their market for feed crops disappears. Because of this situation, dryland operators may be unable to buy sufficient feed crops from the irrigated farms to feed their livestock through a drought . . . "[38]

[37] Huffman, *op. cit.*, p. 131.

[38] *Loc. cit.* (my italics.) This imbalance between irrigated and dryland economies has been highlighted also by Elmer Starch, "The Future of the Great Plains Reappraised", *op. cit.*, pp. 923-924.

It will be shown in a subsequent article that these warnings by Huffman have a direct relevance to the situation in the southern Murray Basin where "off-farm" integration is entirely unsystematic in character and tends to suffer from the shortcomings he mentions.

(ii) The second type of "off-farm" integration involves the exchange of stock between dryland areas and irrigated areas, usually from the former to the latter for fattening purposes, although movement can be in the reverse direction. This has developed to a marked degree in some areas of the United States.[39] Huffman stresses that, like the exchange of feedstuffs, it is less obvious than joint use of irrigated and unirrigated land but, nonetheless, "of great importance in extending the influences of irrigation into the surrounding area".[40] However, this form of integration can also "get out of balance".

(iii) A third type of integration between irrigation districts and dry farming areas is worth mentioning, although it is a form of integration not discussed in the balance of this article. Studies of the economic benefits of irrigation projects recognise that the effects of irrigation do not stop at the increased incomes on irrigation farms. Where irrigation and dryland economics are juxtaposed

> "it is probable that more subtle influences of irrigation on the whole surrounding are also at work. Illustrations of other influences of irrigation on its surroundings may be (1) a larger and more stable tax base which would stabilize the whole structure of local public institutions, (2) enhanced and stabilized local business would make possible more stable and efficient local markets to the advantage of dryland operator and irrigator alike, and (3) industrial activities relating to irrigation farming which would further enhance and stabilize the local economy".[41]

It is apparent that an integration between irrigation and dryland areas involving such secondary and tertiary benefits of irrigation projects is quite characteristic of many areas of the southern Murray Basin, even in the case of projects along the Mallee-Murray areas where few other forms of direct integration between irrigation and dryland farms occur. This more vague link between irrigated land uses and dryland economies is much harder to quantify, although most would agree that it should receive prominent consideration when discussing the stabilising value of irrigation in an agricultural economy faced with production uncertainties.

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[39] There are numerous references to economies which involve exchange of stock from one region to another. Some of these have already been listed. In most cases, integration is not reviewed as the main theme of these studies. Examples are: D. C. Crossfield, "Farming in the Rocky Mountain Trench of British Columbia", *The Economic Analyst,* Vol. XXVII, No. 6 (December, 1957), pp. 125-131. Eugene Mather, "The Production and Marketing of Wyoming Beef and Cattle", *Economic Geography,* Vol. 26, No. 2 (April, 1950), pp. 81-85. Harold A. Hoffmeister, "Middle Park and the Colorado—Big Thompson Diversion Project", same *Journal,* Vol. 23, No. 3 (July, 1947), pp. 220-231.

[40] Huffman, *loc. cit.*

[41] Ward and Kelso, *Irrigation Farmers Reach Out Into the Dry Land,* Montana Agr. Exp. Sta., Bull. 464 (September, 1949), p. 33.

North American Field Studies: Lessons for Australia

A number of field studies have been carried out in the United States to examine the economic character and merits of integration.[42] These have included, in particular, studies of factors promoting or inhibiting the development of integration in the Missouri Basin involving areas of "high plain" forming part of the Northern Great Plains. Particularly significant have been the studies of the North Platte irrigation project, the Milk River and Huntley irrigation projects, and other selected studies in Montana. The possibilities of integration in new irrigation schemes in North Dakota have recently come under review, whilst the concept of integration has received emphasis in proposals for general development of the Missouri Basin in the recommendations of the President's Water Resources Policy Commission.[43] In general, it seems that integration is featured less in existing projects in North America than it is in Australia, although, for climatic reasons, it tends to be more stable there.

The *North Platte* irrigation project[44] is located on the river of the same name astride the border between Nebraska and Wyoming and within the Missouri Basin. It lies at the junction between the Great Plains proper and the hilly country termed the "North West Ranching region". This zone experiences an average of 15-20 inches of rainfall per annum with cold winters (average January temperature of about 25° F.) and mild summers (average July temperature of about 72° F.). The survey of this area concluded, *inter alia*:

> "Integration of the economy of the irrigated valley with that of the surrounding dry-land country comes about through the use of land, exchange of labour, exchange of livestock, exchange of livestock feed, exchange of farm-produced fertilizers, and through the use of a mutual market for crops and livestock. In addition, the dry-farming and irrigation-farming economies are integrated in a less tangible way through educational, recreational, and other public facilities."

However, integration had developed only in a relatively immature way in the North Platte valley by the time of survey and was of chief benefit to the irrigator. This was due mainly to the fact that the surrounding dry land farming (wheatgrowing and livestock ranching on an extensive scale) was basically sound for the climate of the area, regardless of any stabilising effects of the irrigation lands. Also, neither the irrigation farmer nor the neighbouring dryland farmer were tied to one another by any hard and fast buyer and seller relationships since each had lucrative opportunities in other directions. The report on this survey lists other factors that have hindered irrigators' attempts to develop more active integration such as: unavailability of dryland pasture for the irrigators, high percentage of tenant farming on irrigation areas, lack of capital and experience of livestock feeding among irrigators, difficulties of spreading time and machinery to include both dryland and irrigation farming in a system of "on-farm" integration and, finally, the compactness of the irrigation areas which meant that many irrigation farms were not juxtaposed with dry areas (a factor favourable to

[42] Most of these studies are referred to by Huffman, *op. cit.*

[43] *Op. cit.*, Vol. 2, p. 195.

[44] Elco L. Greenshields and Stanley W. Voelker, *Integration of Irrigated and Dry-Land Farming in the North Platte Valley in* 1946 (Washington: U.S. Department of Agriculture in Co-operation with U.S. Department of Interior, 1947).

integration). Despite the lack of ties with surrounding dryfarm areas, some integration existed with more remote livestock regions, because, where stock fattening was being practised, it tended to embrace stock purchased from distant dryland areas that were in a better position to sell stores to the irrigators at an opportune time than were more proximate breeding areas.

The *Milk River* irrigation project[45] is located on a tributary of the Missouri River in northern Montana, again at the edge of the North West Ranching Region on the northern Great Plains. The area experiences an average annual rainfall between 12 and 14 inches; it has cold winters (average January temperatures as low as 12° F.) and mild summers (average July temperatures of about 64° F.). *The Huntley Irrigation* project[45] on the Yellowstone River of Montana has a slightly more equable climate and a somewhat higher rainfall (average 16 inches per annum). In contrast with the North Platte area, integration was very active in these two projects. Many of the irrigators had made definite moves to develop active "on-farm" integration by acquiring dry country and the survey showed that this development was due to:

(i) The need for more grazing (as opposed to crop) land to accommodate stock.

(ii) The acquisition of dryland enabled irrigators to increase the scale of their operations.

(iii) The need to develop a more balanced farm programme by introducing stock to utilise the additional feed which irrigation produced. Dry country was necessary to carry this stock for part of the year.

(iv) Integration opened up the possibility of developing joint and supplementary enterprises.

The survey of these two irrigation projects in Montana showed that differences in the type of irrigation product caused marked differences in the development of integration. Farmers specialising in the intensive production of row crops were less interested in integration than were the operators of larger farms specialising in sheep and cattle raising. These differences in irrigation land use could be explained chiefly in terms of the varying character of soils. The pattern of integration was to be explained also partly in terms of the degree of production uncertainty faced by dryland farmers. In general, higher uncertainty of production in the areas surrounding the Milk River and Huntley projects tended to favour integration more than was the case in the North Platte Valley. However, despite the relatively active character of integration in the first two projects, the survey concluded that only limited amounts of feed were available to dryland areas from irrigation land and this would restrict the value of integration to "spotty" rather than severe droughts.

Huffman and Myrick[46] have shown that integration between irrigated and unirrigated land uses was prevalent in other parts of *Montana* where various Government irrigation schemes had developed. Of one hundred farms

[45] Ward and Kelso, *Op. cit.*

[46] Roy E. Huffman and D. C. Myrick, *Farm Organization and Production Requirements in Selected Irrigated Areas,* Montana Agric. Exp. Sta. Bull. 453 (October, 1948).

studied at random from selected projects, about two-thirds had appreciable areas of unirrigated crop land or grazing land which was linked with irrigated country. Similarly, Voelker[47] has shown that integration of an "on-farm" type was prevalent in the cases of the *Lewis and Clark* and *Buford-Trenton* irrigation projects of North Dakota. A number of dryland graziers had developed 40 to 60 acre "feed base units" as part of the original design of these irrigation projects. However, these surveys emphasised that the demand of dryland graziers for this type of integration varied greatly with seasonal conditions, being high during and immediately after prolonged drought but low in better seasons. The relatively well developed character of "on-farm" integration revealed by Voelker's studies is in contrast to the almost complete absence of integration reported by Stewart and Myrick in 1951 for the *Buffalo Rapids* irrigation project of Montana.[48]

In 1956, Schaffner[49] published an account of the developmental problems facing irrigation during future years in *North Dakota.* A major consideration was the promotion of integration of "irrigated tracts into the existing farm and ranch pattern." This study provides a concise account of the "costs and changes in farm organisation" which the farmers of that area will need to face as the area develops a system of "partial" irrigation, much along the lines adopted in many districts within the southern Murray Basin. Major developmental problems highlighted by this study were:

(i) The need for advice to farmers on techniques of irrigation during the initial stages.

(ii) The increased managerial skills required by a combination of dryland and irrigation farming.

(iii) The problem of meeting the competition for labour between the various sectors of an integrated economy.

(iv) The need for sufficient credit to permit necessary capital investment.

(v) The problem of finding crops which are sufficiently valued to pay for additional costs incurred by irrigation.

Although the concept of integration has been highlighted by a number of writers during recent years in the United States, it would seem that most of the group irrigation projects (but not the unit farm schemes) in that country have not been designed to encourage integration. Steele has pinpointed the problems of irrigation development in semi-arid areas of the United States and the lack of integration in many past projects:

> "In the past, development of irrigation has been confined to the western or drier portions of the Plains, except in the Platte Valley where favourable circumstances have encouraged development in the eastern Plains. Present plans would develop a large amount of irrigation in the eastern Plains. In this area, rainfall is sufficient for full production in some years. In other years, however, precipitation is so low or poorly distributed that crop yields are severely reduced. This variable rainfall may be contrasted to the more

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[47] Stanley W. Voelker, *Settlers' Progress on Two North Dakota Irrigation Projects,* North Dakota Agric. Exp. Sta., Bull. 369 (June, 1951).

[48] Clyde E. Stewart and D. C. Myrick, *Control and Use of Resources in the Development of Irrigated Farms,* Montana Agric. Exp. Sta., Bull. 476 (October. 1951).

[49] L. W. Schaffner, *An Economic Analysis of Proposed Irrigation in Northern North Dakota,* North Dakota Agric. Exper. Sta., Bull. 404 (September, 1956).

arid condition where production almost entirely depends upon irrigation. Many economic problems are being encountered in designing irrigation systems to meet these fluctuating needs. Cost of irrigation development in the Plains is proving to be high. It has been partly justified on the basis that it will add stability to the agriculture of the entire area. Studies indicate that existing irrigation projects have added little to the stability of adjacent dryland areas except in cases where dry and irrigated lands are in the same operating unit. Further investigation is needed to discover ways of organizing irrigation so that it will contribute the maximum to stabilizing surrounding areas".[50]

Starch has shown the growing value of unit farm irrigation schemes in the Great Plains in recent years, schemes

" . . . which have been very largely of the type which added to the winter feed production of the ranch, or of the type which provided for the bridging of winter-summer droughts, as in the case of the pump irrigators of central Nebraska.

Irrigation systems, both large and small, must undergo a process of being adapted to a sub-humid climate if they are to give full results. First, they must be designed to give insurance against the effects of intermittent drought. Second, irrigation production must be fitted into an existing agricultural pattern. Third, the availability of water must be flexible.

Eight pilot projects which were established nine years ago to test the usefulness of small irrigation projects of ten to twelve thousand acre size scattered throughout the Great Plains embody the principle of an efficient design for farms . . . The integration of these projects into a surrounding agriculture has not been adequately tested as yet".[51]

Schaffner has pointed out that the new projects of North Dakota "will be a pioneer effort because few major irrigation systems have been installed where all the land is privately owned and included in existing farms. Much of the irrigation experience has been in the arid areas of the west, where the land had little agricultural value until water was available, and much of this land was public land. Also, there has not been too much experience with irrigation in the semi-humid regions. For these reasons, it is hard to predict the type and sizes of irrigated farms that will develop in the proposed irrigated areas in North Dakota".[52]

Conditions in south-eastern Australia have tended to be more favourable to integration in some respects than has been the case in the United States. Many of the irrigation projects of the southern Murray Basin were begun in areas where all or most of the land was in private hands and where systems of farming had developed without irrigation under sub-humid to semi-arid conditions, even if inhibited by production uncertainties. This is one of the reasons why "partial" irrigation has been much more of a feature of group irrigation projects in Australia than it has in the United States. However, in some senses, the climate of the Great Plains, the northern areas in particular, has been more conducive to a permanently stable system of integration (where it has developed at all) than is the case in the southern Murray Basin.

[50] Harry A. Steele, "Physical, Economic, and Social Factors in Formulation of Land Use Policies in River Basins", *Journal of Farm Economics,* Vol. XXXI, No. 1, Part 2 (February, 1949), p. 403.

[51] Starch, "The Future of the Great Plains Reappraised", *op. cit.,* pp. 922-923.

[52] *Op. cit.,* p. 3.

The northern Great Plains of the United States and the interior lowlands of the southern Murray Basin have certain physical features in common such as relatively low and erratic rainfalls typical of the semi-arid regimes and of particular hindrance to cereal growing and extensive livestock farming common to both areas. However, it is important to note the difference between the two regions. One important difference is that, because of their higher relief and latitudinal position,[53] the northern Great Plains are faced not only with an uncertain pattern of rainfall but also with problems of severe seasonal changes in temperatures. Non-irrigated hill and "terrace" country adjacent to irrigable "bottomlands" and, more especially, the higher country flanking the plains (the uplands of the Rockies) have winters which are too severe to permit all-year-round grazing in many cases. The result is that economic development of these lands depends in large measure on an intimate tie with areas affording seasonal outlet for stock. This need for a link between breeding and fattening areas is a permanent one and, to the extent that irrigation offers a sound basis for fattening enterprises, so a permanent demand exists in many of the dryland areas for integration (chiefly of an "off-farm" kind). In contrast, many farms in the unirrigated riverine plains and Mallee country of the southern Murray Basin, *at their present level of economic development,* have not the same need in many years to integrate their activities with other more favoured areas, such as irrigated country. They do not suffer from problems of seasonal temperature changes and the problem of serious moisture deficiency is somewhat less frequently felt in some of the hinterlands of irrigation projects. Therefore, under present circumstances, there is understandably less interest in "off-farm" integration in southern Australia than has been in evidence in parts of the western United States. However, this is not to argue that the concept has little or no relevance to the Australian scene. Integration becomes very much more vital in Australia once one considers either of two possibilities:

(i) The scope for developing a better integration between irrigation in the red-brown soil areas of the plains with semi-arid country removed from the irrigable zones but faced with problems of climatic uncertainty at present levels of management. There seems no reason why integration should not embrace areas hundreds of miles apart, *i.e.,* why irrigation in the 15-20 inch average annual rainfall belt of south-eastern Australia should not be permanently integrated with stock breeding in the more arid areas of the interior or the inland tropical areas of northern Australia.

(ii) The possibility that any move to greatly increase productivity in the wool growing regions near the irrigation districts (*i.e.,* in areas now not greatly concerned with integration in many years) may quickly meet difficulties of feed shortages that only irrigation could meet in severe drought.

Thus, whilst a case can be made out for the argument that the environment in western America makes integration more economic than it is on the irrigable plains of the southern Murray Basin, this argument should not

[53] For example, the semi-arid country of the Great Plains varies in elevation from between 3,000 feet to 4,000 feet above sea-level. In contrast, the riverine plain and Mallee country of the southern Murray Basin is mostly below 600 feet above sea-lēvel. In addition, whereas the Great Plains lies between 26-49 degrees north latitudes, the southern Murray Basin lies between 34-37 degrees south latitudes.

be extended to rule out the merits of integration as a national approach to linking different regional developments and to cater for the demands of future agricultural expansion in areas now dependent on rainfall.

Several studies of land use in Canada have highlighted the merits of regional integration of land use, although this stems greatly from very cold winters. Darcovich[54] has provided a study of the character of farm organisation and resource productivity on a group of beef cattle farms in Alberta, whilst Whiting[55] has provided a study of feedlot finishing of cattle and sheep in the irrigated areas of southern Alberta. Climatic conditions in these areas (somewhat comparable to the northern Great Plains of the United States) make integration between regions suitable for stock breeding and those suited to fattening of prime importance to the beef industry. Irrigated land plays a significant role in many "feedlot" fattening enterprises, and Darcovich's study emphasises the role of irrigation and other techniques of adapting farm production to uncertainty (such as those listed earlier on page 257). "Prairie ranches" in Alberta face greater problems of lower and more uncertain rainfalls than do "Foothill ranches" and one reaction to this (apart from larger farms) is the trend towards the marketing of younger animals from the former zone. In addition,

> " . . . finish feeding allows the production of better quality beef and more flexibility in output. Without finish feeding ranchers and other grass producers sell mostly calves, long yearlings and long two-year olds, with production periods of about 18, 30 and 42 months in length. Finish feeding can add three more stages . . . yearlings, two-year olds or three-year olds.
>
> " . . .Greater flexibility makes for more efficient output under conditions of uncertainty; it can also reduce uncertainty itself by reducing the over-all length of the production period, if the effect of finish feeding is to put younger animals into the feedlot.
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> "Much of the finish feeding of cattle in Alberta depends on the splitting up of the complete production process between the producer who raises animals on grass and the feeder who buys these animals and finishes them in a feedlot on grain and other feed.
>
> " . . . The organization of the highly commercial, highly specialized feedlot enterprise in irrigated areas can hardly be compared with other feedlot enterprises in the province or elsewhere in Canada. It is unique, both in regard to the supply of feeders which are obtained from nearby ranches and in the supply of feed which is obtained from production under irrigation."

Australian Interest in Integration: Some Examples

The theory of integration as formalised by American writers has not received much attention in Australia although numerous references have been made periodically to the need for developing irrigation as a means of stabilising dryland production. In large measure, the concept has been basic to "partial" irrigation projects developed on the riverine plains of the southern Murray Basin and Australian irrigation has tended to display a

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[54] W. Darcovich, "Farm Organization and Resource Productivity in Some Beef Producing Areas of Alberta", *The Economic Analyst,* Vol. XXVII, No. 6 (December, 1957), pp. 132-138.

[55] F. Whiting, *Feedlot Finishing of Cattle and Sheep in the Irrigated Areas of Southern Alberta* (Ottawa: Canada Department of Agriculture, 1947).

relatively high degree of integration. However, there is a dearth of detailed information on economic conditions of irrigation farming in this country which would throw light on the relative merits of projects with and without more stable types of integration.

In its Eight Report of 1945, the Rural Reconstruction Commission stated:

" . . . *It will be wiser for the time being to develop irrigation projects which will tend to stabilize existing industries, rather than those which will have as their main purpose the additional production of dried or canned fruits, the marketing of which may offer even greater difficulties in the future than it has in the past.* For instance, the recent cycle of drought years which has afflicted many of the southern parts of Australia has resulted in a loss of about 21,000,000 sheep, and to-day the flocks of Australia are little larger than they were in 1891. It is certain that if the relatively small amount of irrigation land used for pastoral purposes had not been able to carry a considerable number of additional sheep and other livestock, the losses would have been very much greater. If areas of irrigated pasture had been more widespread and greater in extent they would, if effectively managed from the stocking point of view, have been able to exercise a much greater influence and reduce the losses of this recent disastrous period.

" . . . Particular attention should be given to the development of irrigation as an ancillary to live-stock industries in the drier regions. The opportunities which irrigation affords for increasing the production of citrus and dried and canned fruits enormously exceeds the capacity of Australia to sell such products. On the other hand, we know we have to face periodic droughts in the course of which both sheep and cattle die in large numbers. This wastage is often devastating to the individual and prevents progress in the industries concerned because as such large stock losses are possible the owners rightly hesitate to make the outlay necessary to improve them in type. If this view is correct the economic basis of such irrigation developments will mainly be in reducing losses by carrying stock more securely rather than in increasing the returns by carrying greater numbers. The additional stability of volume of production would be of value from the point of view of marketing the products. Such developments have not the sensational appeal of applying irrigation to new industries but their ultimate effects may be even more profound."[56]

Similar references were also made by the Commission in its Third Report to the need for using irrigation to assist production stability. No doubt these and other recommendations influenced the decision to extend the principle of "partial" irrigation in southern New South Wales in the early post-war years.

During the past decade, there has been increasing interest throughout Australia in the possibilities and problems of increasing the level and efficiency of wool production. In 1944, Willoughby emphasised the need for a reappraisal of irrigation projects in the sheep areas of south-eastern Australia considered in the light of their possible contribution to enhancing the output of wool. His paper contains some of the most direct and lengthy references by an Australian which bear on the subject of integration and it is worthy of close re-examination. In his reference to irrigation in the southern Murray Basin Willoughby expressed the view that

" . . . most pastures and fodders grown under irrigation are used for dairy and fat-lamb production. Country which was devoted mainly to wool growing before the provision of irrigation facilities has, depending upon the

[56] The Rural Reconstruction Commission, *Irrigation, Water Conservation and Land Drainage,* Eighth Report (Canberra: Commonwealth Government Printer, 1945), pp. 25 and 77. *See also*: The Commission's Third Report, *Land Utilization and Farm Settlement* (1944), pp. 25-26.

amount of water available and the consequent proportion of land irrigated, changed its livestock types and methods of husbandry and, on the irrigated land, the carrying capacity has been increased.

" . . . At present, water is being used to increase carrying capacity for lamb production on the small proportion of irrigated land, and drought protective measures aimed at stabilizing the flow of output are not by any means the general practice. Since evenness of output is an important factor in price returns the use of irrigation water for meat production would appear to be more soundly based on this latter aspect, than on supporting a temporary increase in normal years.

" . . . Only a very small proportion of the water resources are used for the production of pastures or fodders specifically for the stabilization of the wool industry. Yet, this is the Commonwealth's most valuable industry, unprotected by tariffs, unsubsidized by bounties, annually contributing almost half of the export wealth, but experiencing large fluctuations in production due to an erratic rainfall and suffering severe losses by drought."[57]

Willoughby illustrated the high correlation between variations in both sheep numbers and wool yields on the one hand and rainfalls in the wool producing districts of south-eastern Australia on the other hand. He stressed that, in view of the national importance of wool production, research should be devoted to problems of ironing out these fluctuations. In his view:

"The production under irrigation of cheap supplementary pasturage and fodder of the right type would be a substantial contribution to the individual grazier and to the stabilization of the wool industry as a whole. Such use of irrigation water necessitates an approach of completely different character from intensive irrigation such as horticulture, rice, wheat and even dairying, where the aim is maximal return per unit of land. The production of these latter crops, particularly horticulture, requires the development of closely settled areas. This involves high capital and maintenance costs which must be at least partly repaid by a high yield from high quality crops. Consequently, water is made available as far as is practicable in completely sufficient quantities and at the correct times to serve those ends.

"With pastoral irrigation designed to stabilize an existing widespread industry, it becomes necessary to spread the available conserved water over as great an area within erratic rainfall districts as possible, so that each property may have a fair share. Then it becomes the responsibility of each landholder to use his quota of water on the soil type and over the acreage of suitable land that will most benefit his livestock as a whole. The objective on each irrigated acre is the optimal, not the maximal, yield per unit of water.

"Nor is yield alone the criterion of efficient pastoral or fodder irrigation . . . A high protein content is necessary for wool production, and a steady supply in the diet is necessary for evenness of staple. But the native pastures, which in the greater portion of the sheep areas cannot be replacd by introduced pastures, do not fulfil this function. Lines . . . points to summer and early autumn protein deficiency in the winter rainfall zone, and Davies . . . to irregularity of protein supply in the zone of summer rainfall. Consequently, the greater the amount of actual protein as pasturage or conserved fodder that can be obtained by irrigation from each unit of water *for the purpose of supplementing the native pasture in periods of protein deficiency, then the greater is the degree of stabilization to the sheep industry within and surrounding the irrigation districts.*

". . . The use of present irrigation areas for the purposes of livestock protection depends on their proximity to sheep districts of low or erratic rainfall.

[57] W. M. Willoughby, "Irrigation and the Wool Industry", *Journal of the Australian Institute of Agricultural Science,* Vol. 10, No. 3 (September, 1944), pp. 103-104.

"Those within the region comprising the statistical divisions of northern Victoria and the Riverina of New South Wales do offer the means of stabilization and drought mitigation to a large livestock population.

". . . However, the present policy has not been in general along such lines . As irrigation facilities were extended in northern Victoria, properties so supplied changed from insecure cereal and fluctuating wool production to dairying and fat-lamb raising. . . . A similar change is taking place in the new irrigation areas in the Riverina.

"It is suggested on the basis of the foregoing discussion that such use of irrigation water is not in the best interests of efficient land and water utilization. Particularly is this so in the Riverina, where the proportion of unirrigated land is very high.

". . . Regarding future water conservation projects in Australia, pastoral stabilization depends upon the possibility of setting up irrigation facilities supplied by such projects within sheep districts of low or erratic rainfall, or in areas, such as the summer rainfall zone, where the normal irregularity of protein supply results in slow and interrupted growth of animals and their products. The utilization of such pasturage and fodder must be supplementary to the greater area of surrounding natural pasture if the resources of the Commonwealth are to be used to their greatest benefit. For this reason, any future conserved water could well be shared amongst the greatest number of grazing properties in proportions equivalent to their necessities, as has been done in the Riverina.

". . . It must be stressed, however, that the scheme aims at the stabilization of an existing industry, definitely not at an increase of its production, which latter would result in increased misuse of the native pastures and an economic upset in the industry."[58]

Willoughby's comments as quoted above have considerable merit although they tend to assume that irrigation to assist stability of wool production must necessarily involve widespread distribution of water, *i.e.*, by a traditional system of "partial" irrigation (but on more extensive lines) which Willoughby concedes[59] involves " . . . a serious problem" of " . . . water conveyance". As pointed out in other parts of the present study (see pp. 240-1), integration of the type implied by Willoughby could be achieved by combining the concepts of intensive irrigation in compact areas with that of linking irrigated and drylands (which is the aim of "partial" irrigation) so as to achieve the benefits of both approaches.

Sir Ian Clunies Ross[60] has highlighted the environmental and breeding problems which must be faced by programmes to improve the efficiency of the wool industry and has expressed the view that:

" . . . though we are far from understanding fully the part played by nutrition, climate, etc., as compared with heredity in determining the nature of the fleece of the individual animal, it is undoubted that our existing strains of merino sheep have the inherent capacity to produce at least 50 per cent larger fleeces than at present . . . The principal limiting nutritional factors are:

(i) The quantity of food available; and

(ii) The quality of the food, though here again individual sheep show wide variation in their ability as converters of food into wool . ."

These arguments lend weight to those presented by Willoughby on the role of irrigation in providing a higher plane of nutrition in the wool industry. Whilst there has not been general agreement between Australian

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[58] Willoughby, *op. cit.*, p. 105-107. (My italics.)

[59] *Ibid.*, p. 106.

[60] Clunies Ross, "Safeguarding the Future of the Wool Industry", *Journal of the Australian Institute of Agricultural Science*, Vol. 9, No. 4 (December, 1943), p. 158.

writers on the value of supplementary feeding for wool production,[61] experimental evidence of recent years would suggest that feed over and above that available from normal pastures under rainfall might have a strategic role to play in a number of situations.[62] For example: first, as a part of normal operations for higher output in the average year, and second, as a means of saving stock from death during droughts. In the first context, supplementary feed could enable a grazier to carry more sheep during normal periods of lean pasture growth and so ensure that sufficient stock are on hand to make use of pasture growth during the annual season of maximum pasture production, provided this did not lead to the "misuse of native pastures and an economic upset in the industry" as mentioned by Willoughby. Of course, such a situation would present a choice between using additional fodder to raise the nutritional standard of a limited flock and possibly reduce production uncertainties or to carry more stock at a lower nutritional level without reducing production uncertainties. Each approach would have its merits. Another use of irrigated feed (such as lucerne) in integration with dryland pasture might be to increase lambing percentages or to provide a protein supplement for the roughages obtained from unirrigated sources. Similar feed can be used to reduce the loss in lambs before marking and also to increase the size and wool-producing potential of young sheep.

In the second context, that of drought mitigation, there seems to be general agreement that major droughts, whatever their infrequency, make very serious inroads into the sheep industry with repercussions over many years. Although, its merits would depend on the severity of the drought and the price of stock during and after the drought, hand feeding of sheep to save them from death in droughts appears to have a sound economic basis. There is inadequate empirical evidence for gauging the relative values of irrigated and non-irrigated feed supplies to the sheep industry in either of these and other fields and this would vary greatly in any case with the geographic spread and severity of the dry period. In some instances of "spotty" droughts, it might pay to buy grains and other feeds from non-irrigated sources. In other instances of severe droughts affecting very large areas (such as those to 1902 and to 1945), Australian sources of feed other than irrigated areas might not exist in any significant scale and, short of imports from overseas (which raises technical difficulties), irrigation areas might constitute the only source of sufficient feed to save millions of sheep from death.

Whilst the concept of using compact and intensively developed irrigation areas to provide feed for large sections of the sheep industry has an immediate appeal, a serious difficulty which must be faced is the problem of the irregular demand which exists for integration of this kind, at *existing levels of management* in the industry. Wadham and Wood have emphasised this and other problems of integration in their discussion of problems of land utilisation in Australia:

> " . . . Although irrigation areas usually manage to absorb a considerable number of stock from the surrounding districts during a dry season, it would be untrue to suggest that irrigation has largely mitigated the

[61] A. M. Stewart, "Research and the Future of Wool," *Journal of the Australian Institute of Agricultural Science,* Vol. 10, No. 2 (June, 1944), pp. 69-75 and rejoinder by Clunies Ross in Vol. 10, No. 3, pp. 108-113.

[62] See: Alan G. Lloyd, "Fodder Conservation in the Southern Tableland Wool Industry (I)", to be published in the next issue of this *Review.*

effects of drought in the adjacent districts. So far no definite attempt has been made to organize irrigation districts for this purpose. The dry-land farmer himself does not usually understand irrigation and is not, therefore, well-equipped to run an irrigation property unless, as sometimes happens, he has sufficient enterprise to make it a specific part of his business. At first glance it should be practicable to set up irrigation farms with the objective of accumulating fodder reserves against dry periods in surrounding areas. In fact, the farmer in an irrigation district is not in any better position to produce cereal hay more cheaply than his counterpart in any of the well-established hay-growing districts. The price for hay fluctuates widely according to the season, and after a couple of good years, when accumulated stocks are large, prices are correspondingly low. There is no consistent shortage of such hay. It follows that there is no merit in growing hay on an irrigation area unless it is so near the prospective points of consumption as to give it an economic advantage. It might prove possible to work out some scheme whereby livestock owners in the more risky districts would normally have a liaison with some irrigation farm, but until that happens there is little hope of decreasing significantly the losses which occur in the outback areas during droughts. Under existing conditions the irrigation farmer is not personally concerned with what happens to his drought-stricken colleague—his attitude is governed by the price at which he can buy stock for his property."

Discussing "Future Developments" Wadham and Wood conclude:

" . . . It seems that further development of irrigation should aim at stabilizing production on the dry farming areas. To some extent this has already been achieved in the fat lamb and dairying industries. The greater the development of irrigation in proportion to local population, the more necessary would it be to stress this aspect of the use of conserved water.[63]

Thus Wadham and Wood emphasise the need for systems of integration but sound a warning about the deficiencies of systems of land use developed under different management. They might have given more consideration to how future developments in the dryland economies (*e.g.*, a trend towards increased production with greater nutritional requirements) or a more direct management link between irrigated and dryland areas might help to overcome the problems they have raised.

Although it is being developed in a region with physical conditions very different from those experienced in southern Australia, "The Kimberley Project" in north-western Australia reflects the growing interest in using irrigation both for integrated and non-integrated systems of agriculture. Irrigation experiments being conducted at the Kimberley Research Station[64] aim to solve the technical and economic problems of developing irrigation in the far north-west and to provide the basis for developing an irrigation settlement which might "serve as a prototype for similar irrigation settlements elsewhere in the Kimberleys and in northern Australia generally." The immediate aim of the Joint Research Committee, set up to plan and supervise investigations, is to "determine the suitability of the clay soils for irrigation agriculture and to develop a farming system which could provide a basis for the settlement of the area." Whilst consideration is being given to the typically non-integrated types of irrigated agriculture such as sugar and rice growing, it is significant that the Committee is "also conscious

[63] *Op. cit.*, pp. 297-298 and 307.

[64] "Irrigated Crops for the Dry North", *Rural Research in CSIRO*, No. 25 (September, 1958), pp. 10-16. Also "Kimberley Research Station—A Progress Report", *Journal of Agriculture of Western Australia*, Vol. 7 (Third Series), No. 2 (March-April, 1958), pp. 239-257.

of the possibility of improving beef production in the surrounding country by more intensive management, by the introduction of more productive species in selected areas, and by the use of supplements to counter critical feed shortages." Although, the Committee is of the opinion that "it is unlikely that animal industry alone would justify an irrigation settlement" and whilst they stress the need for cash cropping as a basic development, there is no doubt that the problems inherent in the concept of integration have received some close consideration.

Recent proposals for irrigation developments in the Murrumbidgee Valley make little direct reference to the problem of integration. However, the concept has received some consideration in the formulation of recommendations for the types of land settlement to be sponsored by the State Government using waters from early works of the Snowy Scheme. In its Report (1956) on possible forms of irrigation to sponsor following the completion of Blowering Dam, a Committee commented:

"With the development in Southern Australia of winter growing pastures adaptable to supplemental irrigation and filling so well the requirements of sheep breeding, it is understandable that the main demand is to employ irrigation merely for the purpose of lengthening and assuring the growing season to meet the requirements of sheep husbandry. At this early stage in our irrigation and agricultural development, it would be unrealistic and impolitic to sidestep this demand and this phase of development, but this Committee considers that planning should be on the basis of anticipating improved practices and preparing for changing production.

" . . . Without complete information on all these attributes of the land [*i.e.,* detailed soil, topographic and hydrological conditions] planning must be of a general nature. It seems impracticable to make detailed surveys of these types before deciding on the broad programme of development . . . In the absence of this information any recommendations for land-use must be extremely cautions ones, and be confined to land-use forms which are not unsuitable for the most adverse conditions likely to be encountered on a broad scale. This virtually confines consideration to pastoral development.

" . . . Marketing considerations also demand that development be broadly based on pastoral production, particularly meat and wool. Of the animal products, probably wool and beef offer the best immediate and long term marketing prospects, but the economics of beef production under irrigation are at the present general stage of development inferior to fat lamb and cross-bred wool production: similarly the economics of merino wool production are inferior. The immediate economic future of dairy products, especially butter, is very dubious, although in the long run the dairy cow may come into its own as the most efficient means of converting plant protein to animal products, especially animal protein. Other animal production such as pigs and turkeys can only be regarded as minor enterprises.

"There are some doubts about the future of the fat lamb market. With the advances being made in the utilization of our higher rainfall lands, some changes in the structure of the Australian sheep industry must follow. Some breeding country will advance to fattening; and wool (wether) country to breeding, or even fattening. The result will be a large increase in lamb and mutton production. This must have its effect on markets; but the effect may not be serious in the marketing of irrigation produced lambs. These will be produced early in the export season, and, if quality is high and uniform, they should command a market. In any case, irrigation can provide more readily for changes to other forms of animal production.

"The structure of the channel system and the subdivisional system should not only be suitable for immediate purposes, *i.e.,* fat lamb production, but should present reasonable prospects of suitability for other forms of production, as far as these can be foreseen. This means a departure from the partial irrigation scheme: partial irrigation presents the easiest means of fat lamb production under irrigation but the structure of both the channel system and the holdings is unsuitable for any other purpose.

"There is no technical reason why fat lambs cannot be satisfactorily produced on holdings which are virtually wholly irrigated, although this calls for superior management as regards feeding and disease prevention. The inter-departmental committee which recently reported on land-use in the resumed part of Kooba Estate recommended virtually wholly irrigated farms of about 400 acres, using about 400 acre-feet annually for fat lamb production.

"However, it is not to be inferred that farms of such size and structure will continue to be used essentially for fat lamb production. Indeed the aim is to provide farms which will be suitable initially for fat lambs, eventually for other animal husbandry pursuits such as fattening of sheep and cattle, and ultimately for arable farming in conjunction with animal production. Indeed even in the initial stages it is not to be expected that the majority of farmers will rely solely on fat lamb breeding: the fattening of young sheep and cattle are likely to be substantial industries from the outset but in the present unorganised state of these industries the economics of land settlement can be examined only on the basis of breeding fat lambs.

"Such farms would provide flexibility of land-use at least for different forms of pastoral production. Eventual suitability for broad scale field crops would have to be adjudged on an individual farm basis as so many additional factors intrude, but the basic structure does not seem to be unsuitable.

". . . Horticulture and allied intense culture, with their special requirements . . . are in a different category . . . The only course at this stage is to reserve prospective areas from immediate development."[65]

Recommendations for the bulk of the proposed State-sponsored development of irrigation on the Murrumbidgee after Blowering Dam is completed, envisage the creation of farms along the lines of those mentioned above, *i.e.*, farms which will have a high degree of flexibility of land use. The concept of possible active integration of irrigation with dryland agriculture (through stock exchanges) has been considered and is being catered for as a secondary objective. In addition to this prototype of irrigation holding, the same report has recommended allowance of water for private diversion along the Murrumbidgee, some developments to the Hay Irrigation Area, and the encouragement of a co-operative fodder conservation scheme on the lakes area west of Balranald which was proposed by the Lowbidgee League. The development of the latter project will provide a test of some aspects of the concept of integration put forward in this article. Although long distances between irrigated and non-irrigated lands will not be involved, this project should provide a useful guide as to whether a scheme of "spatial diversification" mentioned would be a workable and more desirable alternative in some areas to the traditional separation of management of irrigated and unirrigated lands which is still envisaged for the bulk of new development in the Murrumbidgee Valley. It might indicate the extent to which a system of "spatial diversification" would still encounter the difficulties of integration listed by Huffman. These are: (i) the increased capital and managerial skills required to combine successfully irrigated and unirrigated land uses, and (ii) the fact that integration sometimes might not promote the fullest use of the production possibilities presented by irrigation. In some areas the latter problem might be overcome only by systems of non-integrated irrigation farming.[66]

[65] See footnote 11.
[66] Huffman, *op. cit.*, pp. 133-4.