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Publisher: Routledge

Informa Ltd Registered in England and Wales Registered Number: 1072954

Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

Scottish Geographical Magazine

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/rsgj19>

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Published online: 27 Feb 2008.

To cite this article: J. P. Thomson LL.D., Hon. F.R.S.G.S., etc. (1908) The Murrumbidgee water conservation and irrigation schemes. , Scottish Geographical Magazine, 24:8, 393-415, DOI: [10.1080/00369220808733882](https://doi.org/10.1080/00369220808733882)

To link to this article: <http://dx.doi.org/10.1080/00369220808733882>

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THE SCOTTISH GEOGRAPHICAL MAGAZINE.

THE MURRUMBIDGEE WATER CONSERVATION AND IRRIGATION SCHEMES.¹

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(*With Illustrations.*)

IN dealing with the vitally important matter of water conservation and irrigation it is necessary to consider the subject from the geographical as well as from the purely professional standpoint. And it should be fully understood and generally recognised that the one phase of the subject is even of greater importance than the other in its scientific and economic aspects, since the success of any scheme for the control of a large body of water, its distribution and utilisation for industrial purposes, will largely depend on geographical conditions, their comprehension and careful consideration.

The geographical history of the Australian Continent is one of the oldest, one of the most diversified, and one of the most interesting of all the world's histories. It goes far back, embracing immense periods of evolution and change. In the dim and distant past, the eastern and western parts of Australia were represented by some isolated areas surrounded by the waters of a Palæozoic ocean; in the succeeding Mesozoic ages these islands were united from north to south, extending to Asia, but divided in the central region by an enormous gulf reaching northwards to New Guinea and Borneo, and by the next, or Tertiary period, the continent assumed its present form, and the inland waters or Cretaceous sea were limited to a depression near the junction of the Murray and Darling Rivers, and the lake regions in South Australia. Here we have an explanation of the origin of our inland rivers, and the somewhat remarkable saucer-like structure of the continent, whose central depression is a striking feature. And here, too, we have the

¹ See also the *Queensland Geographical Journal*, xxii.

genesis of the great western plains of New South Wales, the Murray river system and the former grand inland streams that once drained the lofty coastal ranges and emptied their waters into the sea at Spencer's Gulf. But these remarkable alterations have not been confined to the topography of the country alone, nor to other associated land forms, for we know that contemporary climatic conditions have undergone corresponding changes, and that our present rainfall falls a long way short of what it was when the luxuriant vegetation of the continent sustained the gigantic faunal types, whose fossil remains have been disinterred from the post-Pliocene drifts of the Darling Downs and Lake Mulligan.

And this at once suggests to the mind the important subject of the evolution of climate, and the effect of this on the present and future conditions of life, with which man is chiefly concerned. There is abundant available evidence to show that remarkable climatic changes have occurred in the geographical history of the continent within comparatively recent geological times, and we are justified in assuming that such evolutionary changes are still going on and will continue to do so all over the world until animal and vegetable life disappears entirely from the face of the earth. The period of extinction is still remote, but none the less inevitable, and will no doubt be preceded by many changes in the faunas and floras of the globe, each succeeding type possessing some distinctive local peculiarity adapted to the natural environment. Even now we are only just recovering from one of those changes in the form of disastrous droughts, which are so inimical to the life of stock. The position is not a happy one to contemplate, for there is no possibility of improvement in the rainfall of the country, as according to the natural and eternal order of things the periods of excessive dryness must become more frequent, more prolonged, and more intensified as time goes on, until the adoption of some palliative means will become an absolute necessity for self-preservation.

There is no use in assuming an air of indifference to existing or impending conditions on the principle that "sufficient unto the day is the evil thereof," when, as a matter of fact, the extinction of our pastoral and agricultural industries is already threatened by recurring droughts. The position demands some definite line of effective action, and the only remedial measures which suggest themselves at present are the conservation of water and the utilisation of impounded rainfall for rural industries. And in this connection it must be borne in mind that in the aggregate our rainfall is ample, and would meet all requirements were it equally and regularly distributed over the country. But we know that it is not so, and that the evil lies in its uncertain and unequal distribution. Our great aim should therefore be to store as much of the rainfall of wet seasons as will help us to tide over periods of drought. And there is no reason why this should not be done wherever facilities exist for the conservation of water.

In many parts of the country we know that the physical structure lends itself in a marked degree to the impounding of large volumes of water, but the natural facilities for a general system of storage can only be ascertained by thorough and efficient geographical examination. And

in the interests of public life and national prosperity it is most desirable that such examination be undertaken and conducted with as little delay as possible. In some of the States, notably Victoria and South Australia, the necessity for water storage and irrigation has already been recognised in a practical manner, and for many years the subject has occupied attention in New South Wales, where the waters of the Murray River and tributary streams have been gauged, the catchment areas examined, and schemes for irrigating the waste bottom lands of the basin formulated. The matter, under the enlightened policy of the present N.S.W. Government, has now reached an advanced stage, as is about to be demonstrated in a practical and impressive way, by the inauguration of the Northern Murrumbidgee Irrigation Scheme, and the construction of an immense dam to conserve the waters of the Barren Jack catchment area, both having recently been sanctioned by Parliament. It is to a consideration of these impending national works, their bearing on the further development of the State, the advantages of irrigation and water conservation generally to Australian settlement and industrial progress, that the present observations are mainly devoted. I have, at the request of the New South Wales Government, recently assisted in the inquiry respecting these works, and geographically examined the country, including an inspection of the reservoir and dam sites.

Unlike the Murray and Darling, the Murrumbidgee River lies wholly within the territory of New South Wales. Emanating from a source in the elevated tableland at the base of Peppercorn Hill, some five thousand feet above sea-level, and distant a few miles NW. from the town of Kiandra, it flows south-easterly to the left of the dividing Range, which separates it from the head-waters of the Snowy River, to a point about five or eight miles in a north-westerly direction from the town of Cooma. In consequence of the somewhat remarkable *cul-de-sac* configuration of the Main Coast Range and great Alpine chain of the Victorian Cordillera, the river is here deflected for probably one hundred and twenty degrees, and, taking at first a northerly course, runs for some considerable distance parallel with the Goulburn-Cooma Railroad, from which it trends north-westerly to its junction with the Yass River. Down to this point the Murrumbidgee receives the Umaralla, Bredbo, the Molonglo and other important tributary streams, and traverses a tract of country possessing some remarkable features of great natural beauty, especially at the head-waters, where the mountain spurs are steep and rugged, and the lateral valleys deep and precipitous. The catchment area of this region, in the Counties of Beresford, Cowley, Murray, and Buccleugh, and comprising the famous tableland of the northern Monaro district, and the basin of Goodradigbee Creek, is about five thousand square miles. This is mentioned now, as the matter will enter somewhat largely into the discussion of the subject later on. From the Yass River junction the Murrumbidgee strikes westerly, and flowing through the famous Riverina district is joined by the Lachlan River below Hay, and farther down is united to the Murray River at Balranald; the total length of the stream to this point of union being 1350 miles. From its source to the Cooma bend, 170 miles, the average fall of the Murrumbidgee River is about

11 feet per mile, then down to the Yass junction the gradient is lowered to 4 feet per mile, and on to Narrandera to 2 feet per mile.

The lower section, of some 470 miles, between this last place and the Murray junction, has but a slight fall of barely 9 inches per mile, which circumstance favours the inundation of extensive areas of the bottom lands of the basin, when the river is in high flood. The official estimate of the yearly flow of the river at Narrandera is as follows:—

4,000,000	acre feet in a flood year.
2,000,000	„ „ fair year.
1,000,000	„ „ dry year.
600,000	„ „ year such as 1902.

These results are, however, inconclusive, obtained as they have been from rather insufficient observations, covering but a comparatively short period of six years, during which time the river was systematically gauged.

Geographically considered, these physical conditions correspond to three distinct hydrographical divisions of the river basin, in which corresponding changes in the geological structure of the region occur. The first of these divisions includes the head-waters, covering an area of some five thousand square miles, and comprising the catchments of the river and tributary streams, down to the junction of the Goodradigbee Creek, as previously mentioned. For descriptive purposes this may be referred to as the Upper Region or Barren Jack catchment. Here the hydraulic gradients are steep, the declivity of the water channels being sharp, and the numerous tributary streams are consequently rapid and torrential in character when flooded, cutting deep into the rocks and soils, whilst their lateral erosive action augments the sedimentation of the waters, and contributes to the fertilisation of the lands lower down.

The orographical features of this Upper Region are chiefly represented by a circumscribing mass of mountains, the eastern side being flanked by the great coastal range, here from 2000 to 3000 feet high, that stretches away northwards along the whole seaboard of the continent to Cape York, separating the waters that flow easterly to the Pacific Ocean, from the inland waters. On the south and south-west this range is united with the lofty Alpine chain of from 5000 to 7000 feet in altitude, whose culminating peak is Mount Kosciusko, at the head-waters of the Murray and Snowy Rivers. Apart from the magnificent scenery, the panoramic views and the sublime natural beauty of vegetation, hill and dale, which here present themselves, the country is especially interesting to the student of Geographical Science, as being the birthplace of the Australian Continent. Here in the early morn of the Palæozoic period appeared an isolated mass of land, to which in the succeeding age were united other masses along the extensive eastern coastline already referred to. At the beginning of Mesozoic times the lofty summits of the mountains that were crowded together in this neighbourhood must surely have formed a magnificent picture in striking contrast to the present landscape. The range was then over 10,000 feet high, and the stupendous culminating peaks of the Cordillera would probably act as accumulators for the densely

packed vapour clouds, which, no doubt, enveloped the region, precipitating their copious waters on the luxuriant vegetation of the period. The associated torrential rainfalls would sweep down and along the steep and rugged slopes of the mountains, carrying with them enormous deposits of fertile soils to the great river valleys, low-lying plains and marshes below. In this manner the vast central depressions of the continent were filled up and the western plains of the interior formed by the basaltic detritus subsequently washed down in later times from the adjacent ranges. The great inland rivers which then drained the slopes of the rugged coastal ranges and emptied themselves into Spencer's Gulf were amongst the most striking topographical features of the country. As further characteristics of the Upper Region of the Murrumbidgee, it may be remarked in continuation that the physical features of the circumscribed inner area consist chiefly of tableland country and high plains, rising by steeply timbered ridges to the Snowy Mountain Range, where there occurs an extensive tract of treeless downs, of from 5000 to 7000 feet above the sea-level. Here, the snow mantles the surface of the ground for half the year. The northern Monaro Plains are extensive, stretching as they do from Michelago to the range dividing the waters of the Murrumbidgee and Snowy Rivers. With the exception of small isolated patches of stunted trees, the elevated area is denuded of timber and scrub, a condition no doubt responsible for the somewhat inappropriate geographical terminology, "Plains," suggesting flat or level country, while an undulating surface actually occurs, with moderately high peaks in places. Geologically these high lands are of trap formation, basaltic lavas and igneous rocks being abundantly represented over the whole region, with surface stones scattered about in all directions. There is, however, a thick crop of short, sweet grass all over the plains, and this has rendered the district famous for sheep-farming since the earliest days of settlement and colonisation, some of the fine Merino wool, for which the State has so long been noted, being largely produced there.

As to geological structure, the watershed ranges consist chiefly of ancient Silurian deposits of two periods, the lower deposit probably corresponding to the European and North American Cambrian or Laurentian formations. Granites, syenites, porphyrys, and other plutonic rocks are also largely developed on most of the summit ridges of the Alpine chain, and these sometimes occur in the form of intrusive igneous rocks of a later period. But the Palæozoic formations have a wide range, being distributed over extensive areas of the continent, and constituting the principal mountain masses, and the great dividing ranges. They occur in the Blue Mountains, the Pyrenees, the Grampians, and are largely developed in Western Australia, South Australia, and Queensland. To them belong the rich auriferous rocks, the metalliferous strata and the carboniferous beds which have rendered the country famous since gold was first discovered in the early days of settlement. And these ancient deposits are rich in fossiliferous remains, a determination of whose species has thrown a flood of light on the fauna and flora of the continent during the early life of the

world and enabled us to read with tolerable accuracy the history of past ages, of whose physical and climatic conditions nothing could otherwise have been known.

The vegetation of these watershed ranges of the Upper Region, including also the sources of the Murray and Snowy Rivers, partakes more of an Alpine character than the plants found elsewhere in the basin of the Murrumbidgee. The ridges are mostly timbered with belts of mountain ash and other local varieties; but there are elevated plateau lands, locally known as the Snow Country, where tracts of treeless downs are met with, and these latter, being carpeted with rich nutritious green grasses during the summer months, are valuable pasture lands, more especially in times of drought, when stock suffers so greatly on the plains below. Botanically considered this Alpine region, reaching an elevation of 5000 feet above sea-level, and its extension into Victorian territory, possesses some specially interesting features in regard to the wide distribution of plant life and the intermingling of species common to both hemispheres of the globe. While some of the forms are distinctly local in character and peculiarly Australian in type, there are many others corresponding to and not a few actually identical with those of the highland zones of Europe. And this remarkable commingling of terrestrial vegetation is not merely restricted to a few particular genera, but we have it on the authority of Sir Joseph Hooker that it includes many species as well, which circumstances doubtless contribute much to the singular beauty of the flora peculiar to the colder parts of this quarter of Australia, and perhaps in a lesser degree to New Zealand.

The next section of the Murrumbidgee basin will be herein known as the "Middle Region," and extends down to Narrandera. It embraces some hilly and undulating country, and below the Tumut River junction extensive plains are met with, but considered in the light of a geographical unit no striking topographical or even physiographical features present themselves for special treatment.

For pastoral purposes the area under consideration is eminently adapted, but although some patches of alluvial deposits occur at the junctions of most of the tributary streams, such lands are usually too limited for extensive agricultural operations, without the aid of some fertilising agent.

The prevailing geological conditions are here represented by a wide distribution of Lower Palæozoic strata and the occurrence of plutonic rocks, the granites being developed over fairly large but not continuous areas, more especially where hills form the dominant surface features of the country. But these representative formations are comparatively simple in their structure and present no complicated phases requiring further elucidation. The vegetation, too, is likewise typical of the western country, comprising the immense tributary drainage areas of the Murray River system, and is chiefly represented by the ordinary forest timber trees so familiar to the settlers since the early days of colonisation. The various gums, the blood-woods, the stringy-barks, the iron barks and the boxes are readily recognisable amongst the forms met with, and some of these attain striking proportions on the rich

alluvial frontage of the river and tributaries. But the same may be said of many other parts of the continent, for there is a strange similarity about the timbered areas of South-eastern Australia, whose "bush" vegetation is characterised by the sombre and uniform colour of the foliage peculiar to the eucalyptus and the remarkable "scrubs."

The third division of the basin will be designated the "Lower" Region, and extends downwards to Balranald, where the waters of the Murrumbidgee unite with those of the Murray. The whole area is almost devoid of orographical features and consists of extensive plains, some being over fifty miles across, which are frequently treeless. This is especially so in the case of the "Old Man Plain," adjoining Hay on the south, and the "One Man Plain," between Hay and Booligal, both of which sustain patches of saltbush, scattered clumps of stunted trees and nutritious herbage, on which the numerous flocks of the district flourish, the locally grown wool having acquired a favourable reputation for both quantity and quality.

The geological character of the country differs greatly from that of the two preceding regions and is remarkable for a wide distribution and development of Tertiary rocks, distinguishable into Pliocene, Miocene, and Oligocene. This Tertiary group is widely distributed over the whole lower basin of the Murray River system, extending into the south-western parts of Victoria, and terminating at the Ninety-Mile Beach, along the shores of Encounter Bay on the west, and the mouth of the Glenelg River on the east. But there is an interruption to its continuity along the Victorian seaboard, by the occurrence of Primary and Plutonic rocks, notably the granites, which are, however, not developed as a continuous formation along the coastline, but rather in detached masses.

In considering the geographical conditions of this region as a whole, we are led to the conclusion that the Tertiary formation owes its origin to the river drifts of the Murray system that have accumulated for ages on the floor of the basin, gradually filling it up, from remote times, to the present level. And this also furnishes an example of the formation of river valleys, deltaic areas, and alluvial plains, showing a result of the intense erosive action of water on the solid crust of the earth, and standing as an object lesson in the process of reclaiming the great, central depression of the Continent, since the disappearance of the Cretaceous sea.

We are now brought to a brief consideration of the climate and rainfall of these Murrumbidgee areas, their influence on settlement, vegetation, and animal life generally. From the preceding remarks on the orographical features of the basin it will be readily concluded that the upper and lower regions differ very markedly as regards climatic conditions. On the mountain ranges and high tablelands of the former there is a low temperature almost all the year round, the winter cold being severe. In places the snow is heavy, but not perpetual, and does not remain so long unthawed as at the head of the Murray, where, in the higher parts, the shaded slopes may not be altogether uncovered for more than once in every ten years. On the northern Monaro plains and

neighbourhood there are long and cold winters, and even in summer the temperature occasionally falls to freezing-point, when crops susceptible to the influence of frosts may suffer. But, on the whole, the climate is delightfully healthy during the summer and autumn, when out-door life is most enjoyable, the local conditions of climate being certainly superior to those of the Dalgety area, to the south-west, which is lacking in some of the more essential elements to recommend it as a first-rate site for the Federal capital, as suggested by the Commonwealth Parliament. At Cooma, on the elevated plains, 2636 feet above sea-level, the mean temperature is fifty-four degrees and the range falls from a maximum of 107 degrees to a minimum of twelve degrees, but over the whole of this tableland country the mean thermometer reading may be taken at about fifty degrees Fahr. throughout the year, and the rainfall at twenty inches. At the sources of the Murrumbidgee and Tumut waters the isohyctose lines of 50 and 60 inches denote the greatest precipitation that occurs in the district, while the rainfall of the remaining portion of the Barren Jack catchment, or Upper Region, may be put down as varying from 20 to 30 inches. Passing on from here the temperature increases and the rainfall diminishes with the descent of the river, until the lower section is reached, where we find from 12 to 18 inches of precipitation; and in the Middle Region, from 18 to 20 inches, with moderately high summer temperature and cold winters. But in the Lower Region the extremely dry heat of the summer is intense, the mercury sometimes rising to 110 degrees or 120 degrees in the shade, and the range is correspondingly great, for in winter it falls to freezing-point. But, on the whole, it may be noted that, for some eight or nine months of the year, the climatic conditions are agreeable, the winter season being delightfully bracing and eminently favourable for consumptives, or those who suffer from respiratory troubles. Settlers are, however, chiefly concerned about the rainfall, which for most economic purposes is uncertain and deficient, especially so during the occurrence of droughts, whose disastrous effects are not wholly unknown in many other parts of the continent, the only possible remedy being the systematic conservation of water.

This now suggests a reflection on the important subject of evaporation and its influence on large storage supplies of water. It is a matter to which I may fairly claim to have given much attention. My own views thereon have been very fully expressed elsewhere and are set forth in detail in the literary transactions of the Royal Geographical Society of Australasia, Queensland. They embody the results of careful and extensive investigations, covering many years of actual research, and, stated briefly, are to the effect that in every instance examined the loss by evaporation has been greatly underestimated. This is especially so in the case of artesian supplies, whilst the Evaporation observations on the waters of the Murray River system are inconclusive, as they have been made under circumstances in nowise conforming to the natural conditions obtaining. Experiments made on purely artificial data or on the surface of a lake, whose entire sources of supply or means of loss are unknown, or at best merely conjectural, must, in the nature of things,

have little scientific value, and may, as likely as not, be actually misleading. In any case a closer approximation to the truth is more likely to be obtained by assuming that the amount of water lost by evaporation under existing conditions is probably fifty per cent. greater than generally estimated, and on the western plains it is certainly more. At Walgett the yearly evaporation is said to be 65·494 inches; at Wilcannia, 68·976 inches; and at Dubbo, 71·504 inches; these results having been obtained from observations extending over a period of ten years, from 1st January 1893 to 31st December 1902. It would therefore be wise to keep these in view when formulating any scheme for the conservation of water and its application to economic purposes, whether for raising power, irrigating land, or merely watering stock. Especially should these results be borne in mind in utilising the waters of the Murrumbidgee River for fertilising the lands of the Lower Region, where local conditions favouring rapid and excessive evaporation exist in the highest degree, and are probably little inferior to those obtaining in the arid plains of Central Australia, on which the finger-nails break off in brittle pieces under the influence of excessively dry air. As illustrating the widely different views on this subject, it is only necessary to refer to the evidence adduced at the sittings of the Royal Commission on the conservation of water in 1884, in which certain values are assigned to the results of experiments conducted by qualified observers in New South Wales and elsewhere, under varied conditions and circumstances. And, again, we may refer to the masterly summary of such evidence, in which the Commissioners are careful to emphasise the fact that "in the present state of our knowledge upon the subject, opinions vary considerably." They might have gone further and added with equal clearness and cogency that existing experimental methods and appliances are inadequate, and calculated to give erroneous results, the tank system being to my mind one of the most unsatisfactory methods adopted, and one whose obvious defects are the dissimilarity to the natural conditions of a moving liquid mass or even a liquid body at rest. In a comparatively young country like Australia this matter has as yet received but little consideration from those chiefly interested, and yet it is of paramount importance in all enterprises where the economic utilisation of water is concerned. For, in possessing a knowledge of the quantity of water evaporated from a given area, we are not only furnished with information concerning local winds, temperature, and surface conditions, but we are armed with material of great value in the construction of storage reservoirs and irrigation canals, so as to limit the exposed surface areas as much as possible, thereby affording the greatest protection against loss, which in hot and dry localities must obviously be considerable, even after making all due allowance for exaggerated reports and faulty observations.

The economic or industrial phase of the subject of this paper having now been reached, it becomes possible, in the light of the knowledge acquired by our geographical exploration of the area under consideration, to make an intelligent examination of the facilities afforded for the systematic utilisation of the Murrumbidgee waters. In doing so we

must first of all remark upon the evidence of the impermeability of the strata of the Upper Region as revealed by a study of the physical structure of the locality, and the favourable conditions which exist for the storage of large supplies of water. We have furthermore shown that the climate is excellent and the rainfall abundant, while in other respects the area forms one of the best catchments to be found in the whole of the State. It is drained by several important streams of steep declivity

FIG. 1.—Site of proposed Barren Jack Dam.

by which the waters from the melting snow on the lofty ranges and the annual rains are rapidly carried to the lower regions of the basin before suffering any serious loss from local causes. The sources of supply are singularly free from the contaminating influences of physical conditions, and there is no probability of immediate failure through deficient precipitation during normal seasons, augmented as the supply naturally is by periodic snowfalls on the higher levels. With the exception of the Tumut River drainage and some minor streams, this Barren Jack catch-

ment includes the whole of the contributing area of the Murrumbidgee basin, and owing to the natural configuration of the country the gathering ground is singularly circumscribed by an annulating rim of impermeable rocks, which greatly contributes to the successful storage of immense supplies of water, and renders the construction of retaining dams possible. In no other basins of the continent do we find greater natural facilities for impounding a large percentage of the rainfall, and nowhere else are the associated geographical conditions more ideal in their character, more diversified in their scenery, or more typically Australian in their vegetation.

In determining the feasibility or otherwise of conserving the waters of this catchment the question of suitable dam sites requires careful consideration. As a result of detailed examination by officers of the Public Works Department, some three localities have been suggested as affording natural facilities for the construction of dams, that known as Barren Jack having been finally selected. This is situated about three miles below the junction of the Murrumbidgee and Goodradigbee rivers, and distant some twenty-one miles SW. from Bowning, on the Great Southern Railroad, where the river has cut a deep gorge through the ridge of granite rocks that lies across its course, affording natural facilities for impounding immense quantities of water. Here we have an example of the erosive and disturbing action of great volumes of water when confined to the narrow channel of a stream of steep declivity, illustrating in a marked degree the life history of a tributary river flowing through mountainous country. Like many of our Australian water-courses, the Murrumbidgee is but a miniature stream, so to speak, compared with its former majestic proportions, when it was two or three hundred feet above its present level, and spread out over a channel of probably not less than a mile across from bank to bank. In the comparatively narrow gorge between Barren Jack Mountain and Black Andrew the torrential waters and floating ice masses of past ages have left their indelible imprint on the broken and distorted granite masses that are scattered about in all directions, or piled together in disordered and confused heaps elsewhere.

Geographically the locality is bold and rugged in its topography, and the true character of the rock structure is obscured by the chaotic condition of the river channel through the granite formation. Exposed for ages to the influence of the elements, the sides of the gorge have thrown off great masses of granite blocks that are fractured and broken up into all shapes and sizes as they rest on the precipitous slopes or in the bed of the river, concealing the true structural character of the underlying strata. Lithologically considered, the exposed boulder granite rocks are not of an especially good texture, the grain, though fairly fine, not being exceptionally compact and dense. They belong to the Palæozoic series of plutonic rocks so largely developed on the watershed ranges in which the river has its rise, and are not merely of purely local occurrence, but form a continuation of the great system of Silurian strata to which allusion has been made above. Associated with this granite formation in the circumscribing ranges of the watershed are other porphyritic

igneous rocks of Palæozoic age, whose impermeable nature would form an effectual barrier against the loss of impounded waters, rendering the locality an ideal site for a storage reservoir.

Three possibilities were at first suggested for the construction of a dam at Barren Jack, the intention being to raise the barrage in stages to 120 feet, 170 feet, and ultimately to the full height of 200 feet, which would have spread out the time of construction over a period of seven years from the 120 feet stage. But I was not in favour of this proposal, strongly recommending on scientific and professional grounds that the work should be carried on from start to finish without any stoppage. It was finally decided that the dam should "be constructed to its full height, 200 feet, the work of construction to proceed continuously to completion," the estimated cost, including land resumption and protective works, being put down at £810,000. With a dam of this description the reservoir capacity will be 33,380,864,000 cubic feet, and the water area no less than 20 square miles, the Murrumbidgee River being held back for a distance of 40 miles, the Goodradigbee River 15 miles, and the Yass River 24 miles from the dam site.

It will generally be considered that the proposal to carry the dam to a height of 200 feet is extremely bold as an engineering enterprise in a country where experience is not ripe, and all undertakings of the kind must for a long time to come be purely experimental in their more essential characteristics. In a country like America the idea would present no novel features of importance, but to the British mind the case is somewhat different, and in reporting on the scheme I felt obliged to plead for the lower grade of 150 feet, which in my opinion the height of the dam should not exceed. It was pointed out that the impounded water area of the Barren Jack Reservoir will be more than one and a half times that of Sydney Harbour, the storage capacity being little inferior to the great Assuan Barrage of the Nile, while the hydrostatic pressure at the base of the dam will be dangerously high and destructive to the works should any flaw be discovered. The fall of the river and height of dam are greatly in excess of those at the Nile Barrage, where the slope of the ordinary channel for some seven hundred and seventy miles upstream is only about 5 inches ($1/12,000$) per mile, against as many feet in the Barren Jack Area. The exposed liquid surface of the reservoir will be highly favourable to maximum loss by evaporation in a locality such as the Middle Murrumbidgee, where the summer temperature is fairly high and the percentage of humidity low. And it will also be readily understood from the comparatively steep declivity of the river, and from associated local conditions, that the velocity of the water through the dam sluices will be very great when the reservoir is full, rendering extreme caution necessary in such a gigantic enterprise, bearing in mind the lesson afforded by the construction of similar works on the Nile, to which incidental allusion has been made.

From a detailed exploration of the Murrumbidgee River it was found that besides the Barren Jack site there were two other places higher up the stream where the natural facilities were favourable to the storage of water. The remotest of these is located at a place where there is a

deeply eroded channel through the rocks forming the bed of the river, about ten miles NE. of Kiandra. Here the construction of a dam 125 feet in height would impound a considerable body of water of an estimated volume of about 216,200 acre feet, representing the drainage from a catchment area of 128 square miles of high mountainous country, noted for heavy snowfalls and copious precipitations. The other site is below the junction of the Murrumbidgee and Umaralla Rivers, some twenty miles north of Cooma, where the occurrence of a rocky gorge would facilitate water storage. But here under existing conditions of railway improvements and bridge works the height of a dam would be limited to 60 feet. This however would not hold back sufficient water for the purpose of flooding the available lands in the Lower Region, where irrigation works are to be inaugurated as part of the State Scheme under review, and to which some attention must now be given.

From our knowledge of the geographical conditions of this region we are enabled to delineate the characteristic features of the country and to make clear the aridity of most of the area. From the low rainfall of less than 20 inches it must be evident to any intelligent person that, in their present natural state, the lands for all practical purposes are arid and of no commercial value. But the soils would readily respond to the fertilising influence of artificial watering from storage dams higher up the stream, and the Departmental Scheme under consideration is calculated to bring about an entire and greatly needed change in the economic utilisation of this area. The summer thermometer readings are usually high, although on the whole the climate is delightfully genial, but the district thirsts greatly for an adequate water-supply for the development of its agricultural industry, and until this natural craving is satisfied the rural settlement of the locality must necessarily be much restricted. Between Narrandera and Hay there lie on both sides of the river two fairly large irrigable areas, comprising on the north side some 750,000 acres and on the south side 912,000 acres. But for present purposes the former of these has been selected, and in this section the Government proposals are based upon an area of 196,000 acres of first-class lands and 162,000 acres second-class land, or in all 358,000 acres for operative purposes in connection with the storage waters of the Barren Jack Reservoir. For diverting these waters from the main channel of the Murrumbidgee to the service canals a weir and regulator will be constructed at a granite bar near the Bundigerry Creek junction, about nineteen miles above Narrandera, and from this place downwards to the terminal point the supply will flow through a course of 132 miles from the offtake. Including weir and regulators the final estimate for artificial channels or service canals is £764,000, which being added to the former amount put down for the Barren Jack dam and protective works, will bring up the total cost of the scheme to £1,574,000. The diversion site above Narrandera has been selected in preference to any other suitable locality lower down the river, as commanding the largest possible area of irrigable country, as affording the opportunity of utilising the storage waters to the best advantage, to increase the reticulation gradient by diverting the waters from a higher level, and, as Mr. Lee, the Minister

for Works, so ably and tersely puts it, "to get the greatest result possible from the proposed expenditure." With this view I entirely agree. But at the same time the fact must not be overlooked that the length of service canalage will be in proportion to the distance of the offtake from the storage site, and that the loss of water by evaporation, soakage and other contingent causes will be increased in proportion to the extent of country traversed and the distance from the diversion weirs to the fields.

In the scheme under consideration this will likely be considerable not only in the earlier operative stages, but even when fully matured, unless the canals are lined or the water is transmitted through wooden

FIG. 2.—Portion of the Reservoir Area.

or mental troughing. In any case it will be a difficult matter to minimise the loss caused by evaporation in a climate like that of the Riverina district, where the temperature is high and the air exceedingly dry.

I should now like to offer some remarks on irrigation generally, as understood and carried out in other parts of the globe, my own personal observations during a recent tour of the world enabling me to do so with greater facility than would otherwise be the case. Irrigation, it may be remarked, is the fertilisation of land by the artificial distribution of water over its surface. It is necessary for agricultural purposes where there is irregular or deficient rainfall, or in places where the rains do not fall when most wanted. This occurs in many parts of the world, and even in tropical countries the cultivated soils sometimes require to

be vitalised by the application of water from perennial sources, otherwise the crops would fail. The idea of artificially flooding the land for the purpose of crop-raising goes far back into antiquity. In Asia and in some parts of Europe it found practical expression centuries ago, and even among the primitive races the art of utilising the waters of local streams for enriching garden and plantation soils has been long known, and is practised to this day in many places of the world. This is notably the case in the islands of Polynesia, Melanesia and Micronesia, where irrigation in its simplest and most primitive form enters into the economic conditions of life to an extent not usually understood in many countries where it is far more needed, and where, moreover, the greater advantages of enlightened civilisation lend themselves to wider developments and more profitable enterprises in agricultural industries and to a higher appreciation of the value of an adequate water-supply. One of the earliest forms of irrigation consisted in raising river, lake or well water by hand and pouring it on the land. In Egypt this was done centuries ago, when the water was raised by a bucket suspended to the short end of a long pole fixed to a movable axis and balanced at the opposite end by a heavy weight. By these means the water was raised some fifteen or sixteen feet to the land, and even now the numerous small fields that are scattered along the banks of the Nile are watered in the same way. And in northern India the primitive shallow bucket suspended between two strings is used to raise water on to the cultivated fields, where remarkably good crops reward the industrious cultivators, who in the absence of this method of fertilisation would be forced to abandon the land and seek some other means of living. But the broad alluvial plains of fluvial valleys afford greater scope for the development of irrigation works on more modern lines as well as for the accomplishment of large undertakings, according to approved methods, and the inauguration of vast industrial enterprises, for the economic utilisation of river waters. In Italy, for instance, the plains of Lombardy and Piedmont afford a striking example of the results of high-class irrigation and furnish an object-lesson in which every variety of conditions is fully illustrated. Unlike the primitive Polynesians, who divert their river waters at suitable places and carry them on to their plantations by the remarkably effective means of bamboo piping and open ditches, or the Nile peasant, who raises by his counterpoised Shadoof enough water for the fertilisation of his four-acre holding, or the coolie, with his comparatively modern water-wheel, the Lombardy farmers have profited by long experience, and aided by the best class of engineering works, are enabled to utilise the abundant supplies derived from the River Po, lakes Maggiore and Como, and other great sources, to the best advantage. But this is the result of generations of experiments and extended enterprises in a country where the melting Alpine glaciers and snowfields augment the great torrents of the Dora Baltea and Sesia, and render the water-supply inexhaustible and regular. Then again, we have another interesting example of vast supplies as furnished by the Ganges, the Jumna, and the great Punjab streams, used for watering the extensive plains of northern India, where irrigation is met with on a gigantic scale. And

in Southern India too, there are, besides the three great streams draining the Ghats, a series of large reservoirs and tanks whose waters are carried on to the land by a system of canals quite adequate for all local requirements. There is no other country where irrigation is carried on so extensively as in India, and in no other part of the world are the facilities for successful works of the kind so great. In many of the native States tanks and dams are scattered about in all the valleys, and in the territory of Mysore alone there are no fewer than 40,000 reservoirs, the physical conditions of the country being highly favourable to the construction of these. But for gigantic undertakings having for their purpose the conservation of water on a scale unsurpassed in any other part of the world, we must go to Egypt and study the Nile Barrage as well as the great Assuan Dam and Reservoir, which were recently opened with imposing ceremonial, and whose completion within the incredibly short time of four years has astonished the world, and marked another triumph of British engineering, enterprise, and genius. The stupendous nature of this great impoundage scheme, whose chief object is the perennial irrigation of the lands of Upper Egypt, thereby enabling the agriculturist to grow two crops a year instead of one, as formerly, can hardly be realised by the presentation of a series of figures representing the dimensions of the undertaking. But it is interesting to note that the massive granite structure forming the dam across the valley is 6400 feet long, 82 feet thick at the base, and 23 feet at the crest, the whole solid wall rising 130 feet above the bed-rock of the river. The capacity of the reservoir, which is 66 feet deep, and extends for more than 100 miles up the Nile Valley, is 38,000 million cubic feet of water, and the Nile flood is passed through 180 sluice-gates in the dam, capable of discharging 360,000 cubic feet per second. The entire works will command 450,000 acres of irrigable basin lands, and when completed the whole scheme, including the minor dam at Assiut and distribution canals in Upper Egypt, is estimated to cost six and a half million pounds sterling.

And we have it on the authority of Sir C. Scott Moncrieff, to whose most recent writings I am indebted for these statistics, that this will have the effect of increasing land rental by about £2,637,000, and the market value of the land by £26,570,000. But this is not all, and we must take into account the far-reaching influence of such remarkable developments on the general prosperity and industrial life of the territory as a whole. And it must be borne in mind that this influence is not wholly represented by the increased local values to which we have alluded, but there are other sympathising and susceptible elements that have to be noted when considering the scheme in the light of its effects on the country at large.

Although of comparatively recent date, irrigation in the new world has already assumed colossal proportions, and in the Western States of America vast areas of waste lands have been reclaimed, and are now occupied by enterprising and industrious cultivators. At the present time the area controlled by elaborate systems of irrigation there is probably not less than 10,000,000 acres, and these lands, which formerly

were not worth more than from 10s. to 20s. per acre, have now risen to £8, 10s. per acre.

Although timber enters somewhat largely into the calculation of the American engineer there are many of the water works conceived and carried out in the United States on bold and liberal scales, which far surpass any undertakings of the kind in the Old World. But America is a progressive country, where vast tracts of arid lands afford wide scope for the development of great enterprises, and the people there are not slow to recognise the immense advantages of an adequate supply of good water for the fertilisation of the soils. With them the average cost of bringing the water on to the land is about 32s. per acre, and the farmer is charged a water rate of from £2, 8s. to £4 per acre, with an additional payment of from 2s. to 10s. per acre yearly, to cover the expense of maintenance. The cost of service canals vary from £100 to £150 per mile, the former being for a channel 5 feet wide and the latter amount for one 10 feet wide. Having briefly alluded to the progress of irrigation in countries where the economic utilisation of storage water is necessary to the industrial prosperity of the people, I will consider for a moment the comparative conditions under which such works have been established, and the possibility of similar enterprises being carried on profitably in Australia.

In Egypt the rich deposit-laden waters of the Nile, which rise and fall with never-failing regularity, and are unapproachable in their fertilising elements, render the source of supply certain and therefore of the first importance for irrigation requirements. It is in such countries that the lands can be irrigated to the highest state of perfection, and that such is actually the case may be inferred from the fact that in the neighbourhood of Cairo agricultural holdings when put up for sale fetch as much as £150 per acre. In Italy, and in India as well, the source of supply is for all practical purposes unlimited, and this, combined with highly favourable physical conditions for the storage of water and its diversion for economic purposes, renders irrigation possible on such elaborate and extensive scales as in other less favoured countries would not be feasible. In the former country the great rivers and lakes whose precious waters have so wide a fertilising influence on the thirsty plains of Piedmont and Lombardy are fed by the Alpine glaciers and melting snows that have accumulated for ages on the lofty mountain ranges to the north. And the mighty streams of India, rendered famous from time immemorial, are no less remarkable for the immense volumes of water that are brought down in flood seasons from the stupendous Himalayan chain, whose perpetually snow-clad and glaciated summits are inexhaustible feeders of the vast drainage systems which spread themselves out in all directions like a network over wide territorial areas. From these a never-failing supply is derived, supplemented as it is by the copious tropical rains that fall in torrents over the foothills and slopes of the lofty ranges in which the rivers have their origin. And these are actual geographical conditions, which must not be overlooked, for their importance can scarcely fail to leave an impression on the thoughtful mind, to such an extent as to arrest attention and induce consideration,

especially by all whose duty it is to contemplate the subject of water conservation for irrigation purposes or other industrial needs. They point conclusively to the fact that for any system involving the extensive economic use of water the countries under reference are immeasurably superior to the Australian Continent, considered as a whole. And even if we go to America similar conditions exist. In summarising the results of a recent tour round the world in 1903, I had occasion to allude somewhat briefly to this same subject, and, as my views since then have undergone no change, it may be convenient to restate them in so far as they refer to the New World: "In America . . . we meet with vast mountain systems that spread themselves out in all directions over the whole Continent, greatly influencing the climate and materially affecting the conditions of settlement. For many months of the year these lofty regions are covered with snow, which, melting by the heat of a mid-summer sun, gives rise to numerous rivers, whose permanent waters, flowing in winding channels over vast lowland tracts, are a never-failing source of supply to such industrial systems as have for their object the reclamation of arid lands. Suspended on the troubled waters of these mighty streams are the sediments of disintegrated rocks and soils, whose fertilising influence upon the alluvial areas of river valleys has been recognised from time immemorial. The physical structure of the country also lends itself readily to the impounding of these waters and to the construction of service canals for irrigating large agricultural areas. These conditions, then, obviate the necessity for depending upon an uncertain and irregular rainfall, as well as for the construction of vast storage reservoirs, whose exposed waters under the influence of an extremely dry and hot climate would constantly diminish by evaporation and in times of drought probably disappear altogether. They also contribute greatly to the financial success of irrigation systems by facilitating the work of construction and rendering more permanent such undertakings when complete. And it may also be added that the natural surface grade of much of the arid lands of the country is such as to greatly facilitate the distribution of water over immense areas. From the preceding remarks it will be seen that the source of supply is practically unlimited, which must necessarily contribute in a considerable measure to the success of irrigation in the United States of America. Many of the rivers are fed by the melting snows that must always remain a permanent feature of the high mountain ranges there, whilst other streams traversing warmer regions are loaded with the waters of copious rainfalls. These conditions are mostly absent in the interior of Australia, where the rainfall is so irregular and uncertain. In the coastal districts of the Australian Continent the rivers are, as a rule, short and rapid. And in the inland regions the streams carry very little water except in times of flood, and their channels are not usually suitable for the purpose of large storage reservoirs. In the basin of the Murray River and its tributaries the conditions are somewhat different, and altogether more favourable for the irrigation of extensive areas. The melting snow of the great Alpine cluster of rugged mountains in which the river has its source contributes largely to the permanency of

that important stream and affluents, from which a never-failing supply of good water could be obtained for reclaiming the arid lands of the valley below."

Now, in as brief a manner as possible I have endeavoured to contrast the irrigation conditions obtaining in Europe, Asia, and America with those in the Australian Continent, and to show how vastly the former differ from the latter. In point of fact the difference is for all practical purposes as wide as the hemispheres in which they occur, and the realisation of this is only rendered possible to the mind familiar with the physical geography of the world and its important bearing on the economic life of the entire globe. And touching upon this phase of the subject suggests to me the necessity for striking a warning note and of pleading for a purely local consideration of the matter under discussion. Why should we not strike out on original lines and evolve something distinctively Australian in character, suitable to the requirements of the country? It is at once admitted that the American irrigation works are bold and progressive; that in Italy a high-class system of water control has been evolved through generations of experience; and that in India the conservation and utilisation of water is carried out on a large scale, to the manifest advantage of the Empire. But it would be the height of folly to attempt anything of the kind on similar lines in Australia, and no man with a mature and comprehensive knowledge of the wide geographical conditions of the continent would think of advocating or approving of such. In point of fact my personal investigations have convinced me that no human enterprise can possibly establish any system or systems of water conservation in Australia to compare in magnitude with works of the kind in the countries to which I have alluded, and that any attempt at imitation will prove a failure. Indeed it seems perfectly clear to my mind that the failure of the Mildura scheme in Victoria was in no small measure due to too much of the American idea and too little of Australian experience, combined with inadequate geographical knowledge. This, then, suggests to me the necessity of urging that the subject be considered in all its essential bearings from the *local standpoint*. And such consideration must be based upon purely geographical and professional data, without reliance upon the experience of other countries at all.

Now, in sounding a warning note, so to speak, against the folly of undertaking gigantic irrigation projects in this country with the idea of following the example of America, say, or India, it must not be understood for a moment that water conservation is impracticable in Australia. As a matter of fact the case is quite the reverse, for not only is it possible and feasible to store vast quantities of water for irrigating small agricultural areas and fruit plantations along the continental seaboard, but all the coastal districts possess more or less adequate facilities for water storage, and in the basin of the Murray River and tributary streams the conditions are eminently favourable for extensive irrigation works. But there are few other places about which so much can be said. Still, no animal should ever be allowed to perish from thirst, while there exist ample means for conserving a portion of the rainfall that annually runs to waste,

and no arid lands should find a place on the map where they can be watered and profitably utilised. As a matter of fact the losses sustained through the death of stock during periods of drought are infinitely greater than would be the outlay for preventive measures in the shape of adequate systems for the conservation of water. And in this respect I may say at once that I entirely disagree with those who hold that it is not possible to make any provision to minimise or prevent such losses.

We are told that from 1895 to the end of 1900 there have been lost in the State of New South Wales alone some "twenty-five millions of sheep by starvation, in addition to the death of all the natural increase during a period of six years, which in good seasons would have amounted to about twenty millions of sheep more." Now, taking the average price of each sheep as, say 7s., this would mean an actual loss to the State of over fifteen million pounds sterling, within the time specified, which would more than cover the cost of storing an adequate supply of water in all the pastoral districts of the State and leave an ample margin for working expenses. And the same may indeed be said of all the other States of the Commonwealth, where the losses in stock during prolonged droughts are enormous. It is not for a moment contended that there should be a widely extended and progressive movement having for its main object the irrigation of pastoral holdings throughout Australia. But there is no reason why there should not be developed a system of water conservation sufficient for the requirements of starving stock in times of prolonged drought, so as to prevent disastrous loss and obviate the necessity of importing our local meat supply at such periods, and afterwards restocking the whole of the country at great expense and hindrance to trade. In the arid regions of the New World it is not uncommon to grow food for stock on irrigated lands, and numerous fields of Japanese clover, met with in travelling recently through America, afforded sufficient evidence of the success of the industry. It is usual to take four crops a year of this drought-resisting fodder plant off those specially fertilised areas, the yield being from six to eight tons per acre, and there is no reason why similar results should not be obtained in this country, where the soil and climate are even superior. Then there are the agricultural interests of the State to be considered, and these are of wide and far-reaching importance. And in this connection it is necessary to pause and think how much better it would be for all concerned if Australia were in the same position as, say, California, with her splendid fruit supply, and other products of systematically irrigated lands. Nor is it possible to overlook the important bearing of such matters on the industrial life and general prosperity of the entire Commonwealth, which must acutely feel the injurious influences of recurring disastrous droughts, so long as no provision is made to minimise their widely felt effects.

There is no doubt at all that a great deal of the agricultural lands lying within the coastal districts of New South Wales and Queensland could be fertilised very considerably by conserving a portion of the rainfall that now finds its way through numerous river channels to the sea, and is entirely lost to the country which so much needs it. It is not for

a moment supposed that this idea of water conservation is applicable to every stream along the whole seaboard of these States, as there are places where, from my own personal knowledge, the local physical conditions would render the establishment of storage works out of the question. But on the other hand it is known that some of the streams afford good facilities for impounding water, and these should be fully utilised. And, indeed, the same may be said of most of the coastal districts of Australia, where lands are suitable for agriculture. Besides the Murrumbidgee there are in New South Wales the Murray and Lachlan rivers, both of which afford important facilities for the storage of water on a large scale, the former being without doubt the greatest of all our antipodean streams, from the economic standpoint, although it is of comparatively little value as a means of direct communication between the sea and the interior, in consequence of an obstructed outlet.

In Queensland there are several coastal rivers whose waters would be of immense advantage to the industrial life of the State if systematically conserved and economically utilised for the irrigation of agricultural areas and the watering of stock during abnormally dry seasons. The great drawback with some of our Australian rivers is insufficiency of water. In flood times the supply is greatly in excess of the demand, but during protracted droughts the streams fall very low and could probably not be depended on for extensive irrigation. Still in many of the more permanent channels immense volumes of water are allowed to run to waste yearly, instead of being used to fertilise the lands where they are so greatly needed, or to keep alive the vast numbers of sheep and cattle that perish from thirst.

The first step in the direction of water conservation is to systematically gauge the rivers, explore their basins, and locate suitable dam sites. And as this is the work of years, no time should be lost in making a start, for it is necessary that the discharge of the streams should be known in seasons of least rainfall as well as during times of flood, so as to ascertain the minimum quantity of water available for industrial purposes.

As the work involved will necessarily be expensive, and some time must elapse before any return on the outlay could be expected, I would suggest the establishment of a water-rate to be levied on all property-holders who may reasonably be expected to benefit by the storage of water, and that the revenue derived from such rate be set apart exclusively for the purpose of having all our promising or likely rivers thoroughly explored hydrographically and a system of gauging established with the view of instituting irrigation works in suitable localities, where the water supply is found to be adequate. And this can only be ascertained by detailed examination of available data, such, for example, as rainfall, the loss occasioned by evaporation, and other causes, the physical condition of the catchment areas and of the channels. But the work of obtaining this information should be put in hand at once, as it will take many years of patient and careful labour to collate sufficient reliable workable material for the establishment of any extensive system of irrigation. The professional men now employed in the State could

do all that is necessary in this matter, as expert service would not be required for a long time to come, when all the preliminary investigations would be mature and the required data available for special treatment.

For irrigation to be successful in Australia, or elsewhere for that matter, the water should be under direct State control, and the whole enterprise of distribution and utilisation, if in the hands of the Government, should be conducted on strictly business lines. The initial expense of introducing irrigation into a country is usually great, and as a rule there must necessarily be some time of unprofitable labour in preparing the lands for cultivation. Then there is the difficulty and delay involved in settling people on the areas to be watered, and many obstacles to be overcome before there can be any adequate return on the original outlay. But, on the whole, it is desirable that the system of co-operation should form the basis of any movement for the reclamation of arid lands. There is, for instance, nothing better than the results achieved by the Mormons, whose co-operative system in the State of Utah is a monumental example of a magnitude unequalled elsewhere. And this illustration, combined with other less notable though equally successful experiences, suggests the recommendation that all industrial undertakings of the kind should be carried out by private enterprise, the water supply alone being provided by the State, on payment of a fixed scale of charges.

There is no doubt whatever that a great future lies before the Commonwealth, if practical steps be taken to conserve water, to reclaim the waste tracts of the inland districts, and to render more fertile and profitable some of the poorer agricultural areas of the coastal regions. The effects of such an enlightened policy on the part of the authorities would do more to encourage private enterprise; to bring about a lasting prosperity to the country at large; to settle people on the land, thereby increasing the rural population; to restore the confidence of investors, and pave the way for successful immigration, than anything that has ever happened since the discovery of gold and the establishment of representative Government. This is a bold statement, but to those who have studied the history of settlement and colonisation during the last two or three hundred years in other parts of the world it will seem perfectly justified and reasonable. On the other hand, the States will never develop extensively and be so progressive as they ought to be while there is neglect of this important matter. Those engaged in the pastoral and agricultural industries upon which the prosperity of the country so much depends, become dispirited by the disastrous effects of recurring droughts, and in time the whole of the Commonwealth acquires an evil reputation, which spreads far and wide, doing much harm to the best interests of rural settlement and retarding colonising enterprise in many ways. And this in point of fact is a condition which may be said to apply to all parts of the Continent where the rainfall is inadequate and irregular.

In conclusion, the commercial or business side of the subject may fairly claim some slight attention. Viewed in the light of past Australian

experience it cannot be said that the prospects in this direction are remarkably bright. But that is all the more reason why every effort should be put forth to make the Northern Murrumbidgee irrigation scheme successful. We must profit by the failures of our neighbours, and indeed by other failures as well, and learn by experience how to avoid the pitfalls that usually lie before those who set out on new enterprises. The initial stages are mostly difficult to overcome in all pioneering undertakings. And in this particular undertaking there is almost sure to be some delay in getting the right sort of settlers to take up the land to be irrigated. But once the great advantages of the scheme become widely known there will be fewer obstacles in the way and less cause for anxiety as to future success. There is one thing certain, that a step in the right direction has been taken, for the country will always labour under great disadvantages so long as there is no effort made to reclaim the waste lands of the western district and to minimise the effects of drought by the conservation of water.

THE TOPOGRAPHY, HISTORY, AND ECONOMICS OF JERUSALEM.¹

THIS great book presents many sides to the world, and on every one of them it is indeed a great book. As a geographer and historian, Professor Smith has already established a world-wide reputation by his *Historical Geography of the Holy Land* and other writings. For him the two lines are blended, and the geographical study of a land has in it necessarily and always what he has himself so happily termed "the sound of running history." The writer can recall certain well-remembered days when, on more than one hill-top among these very scenes, he watched the Professor as he lay down with map outspread, and swept the horizon or fixed his gaze upon some selected point in silence. Then, with a shout, he would spring up, and explain the landscape, until the swirl of history was all around and below the hill, and the contours of the land had given up their secret. His eye and instinct for the essential geography of a region are unique, and his point of view is ever that of a general marching troops, arranging for their supplies, or working towards an occupation or a siege. From the earliest chapters of the *Topography* you perceive that he is preparing for war, and by the time that you have ended the second volume you have fought over the principal battle-fields of some 1500 years.

Yet the genius of the book is many sided. In the chapters dealing with the names of Jerusalem we find, as we would expect, the thoroughness of the expert in Oriental language and literature. But there is the same free movement and sure step in other lines. The geology, the

¹ *Jerusalem, From the Earliest Times to A.D. 70.* By George Adam Smith, D.D., LL.D. In two volumes. London: Hodder and Stoughton, 1908. Price 24s. net.