INTERNATIONAL
JOURNAL OF
AGRARIAN AFFAIRS
V[illegible] October 1963

The Economics of Water Supply and Control: Pakistan India

Produced by the
University of Oxford Institute of Agrarian Affairs
in conjunction with the International Association
of Agricultural Economists

Price 10s. 6d. net

OXFORD UNIVERSITY PRESS
LONDON

By J. O. JONES

University of Oxford Institute of Agrarian Affairs

THE ECONOMICS OF WATER SUPPLY AND CONTROL. CONCLUSIONS

THE preceding articles on this topic cover many aspects, and together give an idea of the complexity of the subject. Indeed, in many cases the problems surrounding the use and control of water permeate almost all sectors of national life so that to attempt to separate out and to analyse the economics of water supply in relation to the whole situation may appear a practical impossibility or even a near meaningless task. Thus there could be no Egyptian nation without exploitation of the waters of the Nile; and the Netherlands as we know it could not exist without the massive engineering constructions which hold back the engulfing water of the North Sea. As a Netherlands correspondent puts it, '. . . the economic value of being a Dutchman is no part of the study of any institute in our country'. Thus care must be taken to choose an analytical approach which would be meaningful and likely to provide answers of use in present and future situations. However, few of the practical situations with which we are confronted are of the 'all or nothing' variety; more often it is a case of 'more or less' and the object of economic study is to determine where best to draw the line. In other words, we are often faced with problems of marginal adjustments where we are concerned with changes in outputs consequent upon changes in a particular input—in this case, water. Such considerations apply even in countries which are entirely dependent upon water control, such as Egypt.[1]

But here again, great caution is necessary, for although water may be the limiting factor, it is often futile to change water supply without making other changes at the same time. Obviously, the provision of irrigation water may do little to increase incomes unless the cultivators concerned grow suitable crops using appropriate techniques, and are provided with adequate markets. The advantages of provid-

[1] The importance of the Nile waters, the necessity for increased control and exploitation, and the economic aspects thereof, are well brought out by A. A. El Tonbarry and M. S. Abou El Ezz, 'Economics of Water Supply and Control in the Southern Region of the United Arab Republic', *International Journal of Agrarian Affairs*, vol. iii, no. 1, January 1961.

ing irrigation water are sometimes calculated on the assumption that the other necessary changes will take place; but all too often they do not. For example, in the case of the Lis Valley works in Portugal, the traditional crops continue to be grown.[1] In India it was considered that at least a quarter of the irrigation potential created would remain unused at the end of the second Five-Year Plan; and again time lags are found in crop-pattern changes.[2]

Thus for the purposes of systematic analysis it is best to begin from consideration of relatively simple situations in which water is the main variable, and in which few other changes are required to maximize the benefits to be obtained from changes in the water supply. Such conditions are illustrated in already well-cultivated regions of moderate rainfall, such as England, as well as in regions of long traditions of irrigation.

For maximum growth, it is necessary that plants should transpire freely, for not only does water supply the main substance of vegetation, but it also controls plant temperature by evaporation from leaf surfaces. The transpiration rate is governed mainly by the duration of bright sunshine, temperature, wind and air humidity, and does not vary much between one commercial crop and another during the growing season. For any situation it is thus possible to build up what may be called a water balance-sheet based on actual rainfall and potential transpiration showing periods of water surplus and deficit. To some extent surpluses from one period may be carried over to deficit periods by retention of water in the soil, the degree of retention varying with the type of soil. In regions which experience prolonged periods of drought, under natural conditions the choice of crop is severely restricted by the extent of the rainy seasons, and the introduction of artificial water supplies opens up a whole range of new possibilities and problems. Where rainfall is already fairly plentiful and well distributed, but sometimes falling short of potential transpiration rates, the introduction of irrigation is not likely to require any great change in the type of farming or the crops grown in order to obtain full benefit from the additional water. Such are the conditions over a large part of England, particularly south-east of a line from the

[1] Fernando Estacio, 'Economic and Social Problems of Water Supply and Control in Portugal', ibid., vol. ii, no. 5, June 1959, p. 137.

[2] O. P. Anand, 'Some Aspects of Optimum Benefits from Utilization of Irrigation Potentials of Chambal Valley Project', *Indian Journal of Agricultural Economics*, vol. xv, no. 4, 1960, and Nasim Ansari, 'Some Economic Aspects of Irrigation Development in Northern India', above, pp. 13-49.

mouth of the River Humber to the mouth of the River Exe, where in at least one year in two plant growth is restricted by shortage of rainfall, the shortage becoming progressively greater towards the eastern part of the region.[1] Thus for south-east Essex the following balance-sheet may be drawn up.[2]

	April	*May*	*June*	*July*	*August*	*September*
Average rainfall . . .	1·7	1·5	1·4	2·0	1·9	1·7
Average potential transpiration .	1·9	3·0	3·7	3·8	3·2	1·9
Cumulative deficit . . .	0·2	1·7	4·0	5·8	7·1	7·3

Because of the availability of soil water, plants are unlikely to be significantly retarded under these conditions until the deficit reaches about 2½ inches, but of course this varies with the water-retaining properties of the soil, light porous soils requiring more frequent watering than heavy soils. The individual farmer within such an area is thus faced with a fairly well-defined range of action, within which he can assess costs and returns with reasonable accuracy. The difference between potential transpiration and rainfall sets an upper limit to the profitable use of irrigation water; and figures are available[3] whereby estimates may be made of increases in crop yields. Against the value of the increases can then be set the cost of the irrigation. In this way, Nix and Prickett[4] build up a fairly comprehensive picture, based largely on data collected from individual farms, of the likely benefits to be obtained from the most important crops. The results may be summarized:

Typical Yield Increases, Value and Costs

Crop	*Percentage increase*	*Extra yield per acre*	*Value of increase per acre*	*Approx. average irrigation (inches)*	*Likely range of costs per acre*
Early potatoes . . .	40	2 tons	£55	2	£3½–10
Main crop potatoes . .	40	3 tons	£40	3	£5–15
Sugar-beets . . .	20	2½ tons	£12	2	£3½–10
Peas (for freezing) . .	25	8 cwt	£15	1	£2–5
Spring beans . . .	50	8 cwt	£10	3	£5–15
Spring corn . . .	10	2½ cwt	£2–3½	1	£2–5

[1] *Irrigation*, Bulletin No. 138, Ministry of Agriculture & Fisheries, 1954, pp. 42–43.

[2] J. S. Nix and C. N. Prickett, *Farm Crop Irrigation*, Report No. 55. Farm Economics Branch, School of Agriculture, University of Cambridge, June 1961.

[3] *The Calculation of Irrigation Need*, Technical Bulletin No. 4. Her Majesty's Stationery Office.

[4] Op. cit.

Similar benefits are obtainable from grassland irrigation, but this usually entails a greater degree of farm reorganization.

The wide range in costs is a reflection of the availability of water. The lower figures apply when water can be obtained free and the supply is adjacent to the area to be irrigated. As distance increases, so pumping and distribution costs increase, and of course any charges for the water have to be added. The simplest situation is therefore that in which a farmer can increase the yield of his normal crops by drawing water from a nearby water-course, and applying it by sprinklers or rain-guns wherever a rational calculation shows that additional returns are very likely to exceed additional costs.

An article from Denmark shows that the same sort of considerations can be applied there.[1]

Cases of excessive soil moisture can also be looked at in this way. In Norway, for example, Harry Langvatn explains how annual costs of particular drainage projects may be calculated, and against these may be set likely increases in yields.[2] An estimate of the saving in cost from working on well-drained soil can also be made, and from these combined results the individual farmer can form a fairly clear idea of the likely economic benefits of possible drainage schemes. He is likely already to possess the necessary knowledge and technical skill to obtain the predicted results, and, as in England and Denmark, final decisions on the adoption of particular water-control schemes rest mainly with the individual farmers concerned.

Even under the conditions already mentioned, however, freedom of action of individual farmers is not unlimited. In England at present, some farmers can draw water freely from nearby rivers and canals; but as the advantages of irrigation become more generally known, and more farmers adopt the practice, a point will very soon be reached at which existing water supplies will be inadequate to meet the total demand, particularly during periods of drought when the need will be most urgent. Thus what begins as a fairly simple individual farm problem becomes a community problem requiring public works, controlling legislation and, almost inevitably, higher costs to the water users. Extensive irrigation in the south-eastern part of England would necessitate drawing water supplies from the west where rainfall is

[1] Erik Kristensen, 'A Note on Water Control in Denmark', *International Journal of Agrarian Affairs*, vol. iii, no. 1, January 1961.

[2] Harry Langvatn, 'Some Implications of Water Control in Norway', ibid., vol. ii, no. 5, June 1959.

heavier and more regular, and the development of the Grand Contour Canal[1] offers interesting possibilities.

Articles describing the evolution of water supply and control policies in the U.S.A.[2] and Canada[3] illustrate the complexities which arise not only through increasing agricultural demands, but because of the rapidly increasing demand for water for many purposes which arise in a developing economy with an increasing population. Thus the provision of water for irrigation has to be combined and co-ordinated with the use of water for electricity generation, transport, industrial uses, waste disposal and even recreation facilities. Increasing considerations must therefore be given to multi-purpose projects, to the reuse of water, and to economies in use, particularly by industries which have hitherto tended to assume that water was freely available. These two articles show how necessary planning procedures and legislation develop in predominantly 'free' economies, largely by a process of evolution and adaptation. An article from Poland,[4] on the other hand, illustrates how, in a more fully and deliberately planned economy, the whole problem is considered from a national point of view in all its aspects and in terms of a national Water Economy Plan. But in both types of planning great difficulties of prediction must arise, mainly because of unforeseeable developments in technology[5] which render unreliable the projection of existing trends. In the case of industrial development, for example, it is often assumed that the availability of large quantities of water is essential in certain industries such as steel, chemicals and paper; but where techniques are adapted to water saving, quantities used per unit of output may be reduced by nine-tenths or more without rendering costs uncompetitive.[6] Similarly techniques are developing which allow air to supplant water for cooling purposes, in such processes as oil refining and electricity generation. Thus, although estimates must be made of future water requirements on a national or international as well as on a local scale, if the best use is to be made of resources plans must

[1] J. F. Pownall, 2nd Cambridge Irrigation Conference, Farm Intelligence Ltd., 42 Parliament Street, London, S.W. 1.

[2] Harry A. Steele, 'Water Resource Development in the United States', *International Journal of Agrarian Affairs*, vol. iii, no. 5, June 1959.

[3] C. C. Spence, 'Water and Irrigation in Canada', ibid., vol. iii, no. 1, January 1961.

[4] Alexander Tuszko, 'Water Economy in Poland', ibid., vol. ii, no. 6, July 1960.

[5] 'Growing Demand for Water: Product and Cost Allocation', Symposium, *Journal of Farm Economics*, vol. xxxviii, no. 5, December, 1956.

[6] Gilbert F. White, 'Industrial Water Use', *Geographical Review*, July 1960.

be sufficiently flexible to allow for unpredictable changes in requirements for particular purposes. This, of course, is additional to the uncertainties associated with future demand for the final products to which the use of water contributes. Where markets are already well supplied, and price and income elasticities of demand for the products is low, extension of irrigation may lead to an embarrassing increase in supplies which would depress total earnings. Such a situation is possible in North America and Western Europe. Anxiety has been expressed in Greece.[1]

In arid areas, irrigation is often essential for the survival of population. Economic considerations arise nevertheless in connexion with the use and extension of water supplies. In the ancient cradles of civilization, a complex system of methods, laws and customs has evolved over thousands of years, and must be respected as incorporating much practical knowledge and wisdom. Yet many of these systems are tied to traditional methods of agriculture, and to ways of life and forms of land tenure no longer in harmony with technical and economic progress. A. Azarnia[2] describes how, in Iran, vastly complicated systems of laws and practices have developed for the sharing of water in a manner acceptable to the users, and here we see together with systems based on mathematical calculations of flow and rotation the emergence of distribution systems based on demand and cash payments—a process of gradual transition and adaptation to a monetary economy. Peru[3] presents an example of the more complicated but not uncommon situation in which an ancient civilization with well-established cultivation and irrigation practices was overthrown by a European colonial power which attempted to transplant its own system, and which was in time displaced by a national movement. Modern developments have to be planned and evaluated against this background of mixed traditions.[4] Furthermore, in situations where from time immemorial water has meant life, it is often accepted simply that more water means more life, and the massive water works which modern technology has made possible tend to be accepted uncritically as necessarily sound investments.

[1] C. Evelpidis, 'Irrigation in Greece', *International Journal of Agrarian Affairs*, vol. iii, no. 4, January 1963.

[2] A. Azarnia, 'Irrigation Water Distribution in Iran', ibid., vol. ii, no. 6, June 1960.

[3] Jorge M. Zagarra, 'Peru's Water Resources', ibid., vol. ii, no. 6.

[4] In Israel, the situation is further complicated by mass immigration, and the need rapidly to establish additional agricultural areas in a semi-arid climate. See Zeev Kariv, *Water Development and Water Costs in Israel*. International Committee on Irrigation and Drainage, Israeli National Committee, Tel Aviv, 1960.

These works also carry considerable national prestige and, one may suspect, are more likely to attract finance from international sources or from more advanced economies than are more modest projects. But although considerations other than the economic may be important it is necessary to assess the economic returns in order to know what the cost of other benefits is likely to be.

Again it is useful to begin from the simple fact that to achieve optimum rate of growth of almost any crop on a given piece of land at a given time will require approximately the same amount of water. Thus, as Colin Clark points out,[1] it is only sensible to grow the crop or crops giving the highest value of net annual yield per acre, and this often entails changing cropping patterns. Yet his figures show that rice—the most important traditional crop on irrigated land—tends to yield comparatively low marginal returns. The reasons for the continuation of rice cultivation, even where more valuable crops could be grown, is partly due to tradition—as in Portugal—but is sometimes also encouraged by differentially cheap water rates for rice growing, as in Australia.[2] Clark shows that marginal returns to irrigation water are considerably higher for wheat and maize, and are probably highest for fruit and vegetables. However, the large-scale cultivation of the latter presupposes a highly developed domestic or export market, with associated grading and packing facilities.[2]

Articles from Lebanon,[3] Jordan,[4] and Italy[5] show how plans can be drawn up with careful consideration of alternatives, so that a very substantial benefit/cost ratio may be obtained. But in many existing schemes such ratios do not hold, often because of the rapidly increasing marginal costs of irrigation water supply. More readily available sources naturally tend to be utilized first. This increasing marginal cost is strikingly illustrated by figures from the U.S.A., India and Pakistan,[6] in the latter countries the rise being most marked with works constructed since 1920. In view of the shortage of capital in such regions, a net return of at least 10 per cent. per annum on additional costs would seem to be required to justify investment of

[1] Colin Clark, 'Economics of Irrigation in Dry Climates'. University of Oxford Institute for Research in Agricultural Economics, 1961.

[2] C. Evelpidis, op. cit.

[3] Gordon H. Ward, 'Economics of Irrigation Water in the Litani River Basin of Lebanon', *International Journal of Agrarian Affairs*, vol. ii, no. 5, June 1959.

[4] Victor Khoury, 'The Economics of Irrigation in the Jordan Valley', ibid., vol. ii, no. 6, July 1960.

[5] P. Vicinelli, 'Irrigation in Italy', ibid., vol. iii, no. 4, January, 1963.

[6] Colin Clark, op. cit.

this nature; but it may be necessary to allow for a certain time lag and, as pointed out by Nasim Ansari, the total benefits to the region as a whole must also be considered.[1] Of course in some cases, as in the Damadar Valley scheme, the value of electricity generation may in itself justify most of the cost, the amount chargeable to irrigation there being mainly the cost of the water-distribution network. Clark estimated that even under the most favourable conditions, growing the highest value crops, a net return of $\overset{\$}{50}$ 350[2] per hectare puts an upper limit to the value of irrigation water.

Further difficulties arise in assessing the life and the long-term effects upon the land of large irrigation schemes. The rate of silting up of reservoirs tends to be underestimated, particularly in regions of fairly soft rock, such as the Himalayas. In this connexion, re-afforestation, by reducing the soil erosion which leads to silt formation, can contribute to the economics of irrigation. Also, irrigation can be disastrous for the land itself. This is particularly so when the water contains dissolved salts and drainage is inadequate, in which case constant evaporation from the surface together with an upward movement of salt-bearing water into the upper soils increases the concentration of salts in the topsoil to a point at which fertility is impaired. An article in the present number of the *International Journal of Agrarian Affairs* by P. E. Naylor describes how this situation has arisen over large areas of Pakistan, and explains and evaluates methods whereby this land may be reclaimed. Here drainage and irrigation must proceed together and in some cases the water which is used for leaching can be pumped from tube-wells and re-used for irrigation.

In conclusion it is perhaps permissible to speculate upon construction costs associated with irrigation projects. Whereas it is certainly true that additional sources of water tend to become progressively more inaccessible and difficult to utilize, leading to increasing marginal costs, it seems also that types of structure and methods of construction have become increasingly capital intensive. This is a natural development in economies where labour is becoming progressively more scarce in relation to capital, and where full employment at an advanced level of technology and with high wage rates prevails. But the adoption of construction methods based on expensive machinery in areas where labour is underemployed, and where machinery (and sometimes also its operators) have to be imported and paid for with

[1] Op. cit.

[2] $\overset{\$}{50}$ = value of 1 U.S. dollar in 1950.

scarce foreign exchange needs very careful consideration. Particular attention should first be given to the possibilities of using labour intensive methods, with simple tools which can be made locally, using heavy expensive equipment only at strategic points. Not only would such methods economize in scarce capital and increase employment opportunities, but they may well provide a way of utilizing food surpluses of the western world, these food supplies being channelled to workers on irrigation and associated construction projects which on completion would increase employment and income-earning capacity in the areas to be served. Used in this way food alone could contribute up to one-fifth of the total capital required.[1]

[1] *Development Through Food.* F.A.O., Rome, July 1962.