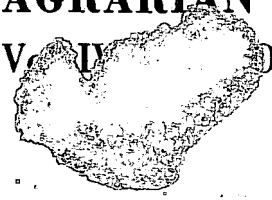
INTERNATIONAL
JOURNAL OF
AGRARIAN AFFAIRS
V[illegible] [illegible] October 1963



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 NASIM ANSARI

University of Delhi

SOME ECONOMIC ASPECTS OF IRRIGATION DEVELOPMENT IN NORTHERN INDIA[1]

UNDER India's Five-Year Plans, high priority has been given to irrigation development, and it is expected that by the end of the Third Five-Year Plan, which is currently in progress, the area under irrigation will have gone up by about 75 per cent. over the level immediately prior to the plans—a level, incidentally, that has taken a whole century to attain.[2] With such rapid growth of irrigation facilities, a number of problems have acquired significance. The object of this paper is to examine some of these problems in the context of circumstances prevalent in the two northern states of Punjab and U.P.

Conditions of irrigation on the supply as well as the demand side vary widely from one region of India to another. However, since physical conditions vary greatly even within the two states under study, one can reasonably suppose that these would present many situations obtaining in the country as a whole.

[1] This paper summarizes some of the results of a larger study, recently completed by the Agricultural Economics Research Centre, University of Delhi, into the 'Economics of Irrigation and Water Rates in U.P. and Punjab' which will soon be available in print. The author worked on this study as a member of the staff of the Centre in collaboration with his colleagues. However, he is solely responsible for the views and opinions expressed in this article.

[2] State outlay on major irrigation works (costing over Rs. 5 crores) and medium works (costing over Rs. 10 lakhs and up to Rs. 5 crores) amounted to Rs. 300 crores under the First Plan, accounting for about 15 per cent. of the total plan outlay of Rs. 1,960 crores. (One crore is equivalent to 10 million and one lakh to 100 thousand.) Under the Second Plan, it amounted to Rs. 372 crores or 8 per cent. of the total plan outlay of Rs. 4,600 crores. In the Third Plan, the proposed outlay under this head is Rs. 599 crores, which constitutes 7·4 per cent. of the total proposed outlay of Rs. 8,099 crores. In addition, there have been state outlays on minor irrigation works, mainly tube-wells, which form part of the outlay on agricultural programmes and have not been shown separately for the First Plan. In the Second Plan the outlay under this head was Rs. 94.94 crores, and in the Third Plan, Rs. 176.76 crores are provided. Some provision for minor irrigation is also made under the community development programmes. (For further details see the *Third Plan*, chap. xix, pp. 304–10, and chap. xxiv, pp. 380–7). Substantial investments in irrigation have also been made by private individuals, but a precise estimate of such investment, specially in net terms, during recent years is not available. The state is, however, the principal investor in irrigation. Major and medium works are invariably state works. Among minor works, tube-wells are most capital intensive and have been of increasing importance. They are also largely state works.

I. *Recent Developments, Problems and Controversies*

The question of recoupment of costs

A major problem is that of recoupment of costs. Investment in irrigation is not one of those public investments of which the benefits are more or less evenly diffused among the entire community, and the costs of which may be debited to the general revenues. There is a group of immediate and principal beneficiaries—the cultivators receiving irrigation. It is therefore necessary to ensure that they are not unduly subsidized by the rest of the community. Moreover, as long as irrigation facilities remain limited,[1] it is only right that the beneficiaries should be called upon to contribute as best they can towards the cost so that revenues are released for furtherance of developmental activities, including extension of irrigation to new areas.

The problem has been complicated for several reasons. The construction cost of irrigation works are now much higher than before. This is not simply due to the steep rise in prices during the days of the Second World War and since. The real costs of construction have also gone up quite steeply because of the need to undertake increasingly difficult projects.[2]

At the same time, in many of the areas recently brought under irrigation, the capacity to pay for irrigation has appeared to be quite low.[3] In other words, it so happened that the areas in which irrigation could be provided cheaply were also the areas in a very good position to pay for it, since they were dry and sandy tracts, with low rainfall, and low subsoil water levels. In recent years, however, irrigation facilities could be extended to such areas only through the construction of a gigantic dam, as for instance to Rajasthan and southern Punjab, under the Bhakra Project on the River Sutlej in northern Punjab. Moreover, irrigation has also been extended to areas of medium and high rainfall and to those abounding in natural facilities for minor irrigation, purely from the point of view of providing security against drought. These areas were given low priority because it was believed that the demand for irrigation would be highly unstable and irrigation

[1] The irrigated area at the Third Plan target level of 90 million acres will constitute only 19 per cent. of the cultivable area and about 28 per cent. of the sown area. The long-term object of the planners has been to bring under irrigation about 175 million acres (100 million acres by major and medium works and 75 million acres by minor works).

[2] See the *First Plan*, pp. 356–7; also the *Third Plan*, p. 387. Real cost of construction of irrigation works may also have gone up in so far as the level of real wages has gone up. Also, *Report of the Indian Irrigation Commission, 1901–03, Part I—General*, pp. 34–35.

[3] Ibid., p. 36.

would not be able to pay for itself. It is this constellation of circumstances—increasing costs and diminishing expected returns—that caused irrigation development to be strictly limited during the earlier decades of the present century.

Criteria for public investment in irrigation

The principle officially adopted for investment in irrigation (familiarly known as the 'productivity criterion') has been that an irrigation work, in order to qualify for construction under governmental auspices, must, from the tenth year of its opening, be expected to yield, through direct irrigation charges, enhanced land revenue and certain other miscellaneous receipts, sufficient surplus of revenue over working expenses (which include all depreciation and maintenance charges) to cover interest at stipulated rates on the sum-at-charge.[1] With scope for construction of diversionary works (which merely diverted water from rivers to irrigation channels) nearing exhaustion by about the turn of the century, and areas remaining to be irrigated being largely in a weak paying position, little further expansion of state irrigation was possible in conformity with the productivity criterion. Indeed, irrigation development would have been even more limited than it was if in the meantime, as a sequel to the recommendations of the Famine Commission of 1880, the principle had not been recognized of subsidizing on a limited scale what came to be known as 'protective' irrigation, aimed at ensuring the traditional level of cultivation.

The 'productivity criterion' has for long been subject to strong criticism. Already during the later decades of the nineteenth century irrigation engineers had criticized it as too restrictive a formula. They pointed to the manifold directions in which benefits of irrigation in course of time accrued which in turn yielded revenues to the various organs of the state (central, provincial, and local) which could not be directly attributed to irrigation and which accordingly were not taken into account in estimating the returns from irrigation.[2] Moreover, it has been argued in recent years, that the relevant consideration should be the total *social* benefit resulting from irrigation (compared to the total social cost) irrespective of the consideration as to what part of it flowed or could flow into the coffers of the state.[3] Distinction

[1] The sum-at-charge consists of the capital cost plus arrears of interest accumulated during construction and non-remunerative periods.

[2] For a very brief review of the early discussions see D. R. Gadgil, *Economic Effects of Irrigation*, pp. 1–2.

[3] Ibid., pp. 2–3.

has been made between primary, secondary and tertiary benefits of irrigation, on the one hand, and direct and indirect benefits at each of these stages, on the other. It has been argued that in view of the basic role that irrigation performs in agricultural development and the latter in turn performs in inducing, promoting and strengthening wider processes of growth, the direct and indirect benefits accruing to other than the primary beneficiaries and also the indirect benefits accruing to the primary beneficiaries must be large, and must be adequately taken into account.

Under the Plans the productivity criterion has not been applied rigorously in practice. On the basis of existing rates of irrigation charges, few irrigation works could be expected to be remunerative. The guiding principle has in fact been to develop the country's water resources to the full and in the optimum manner.[1] Indeed, the question has arisen if we might not have invested too fast in irrigation. Irrigation is only one of the factors in agricultural development, and best results are naturally obtained when there is a balanced development of all the various factors, the yield of each factor being as much a function of its own growth as of the growth of other complementary factors. Many would feel that at present greater profit would be in store in shifting emphasis from irrigation to increased production of complementary inputs, such as fertilizers,[2] and to promoting requisite changes in cropping pattern and other agricultural practices and techniques.

However, the productivity criterion has been waived only in practice. The principle stands, and has been reiterated in all the Plans. And the planners have throughout hoped to remedy the situation created because of the construction of many unremunerative works in recent years by suitably modifying the structures of irrigation rates which have become obsolete due to price rise, and by imposing other forms of irrigation charges which have not been in vogue in the past.

Similarities and differences in considerations relevant to investment decisions and those relevant to rate fixation

In fact what seems necessary is to make a distinction between the question of investment in irrigation and the question of charging for irrigation. For purposes of deciding upon the level of investment it is

[1] See the *First Plan*, pp. 335–8 and 345; the *Second Plan*, pp. 321–6; and the *Third Plan*, pp. 380–1.

[2] See in particular A. K. Sen, 'The Development of Indian Agriculture', two articles published in the *Statesman*, Delhi, 25 and 27 April 1959.

necessary to take into account the total social benefit, but for purposes of charging, the roundabout benefits become somewhat less important. When a work is such that its total benefit exceeds total cost, but its benefit accruing directly to the primary beneficiaries falls short of its cost, the need for deficit pricing is obvious. But if the benefit accruing directly to the primary beneficiaries is large enough, there is a strong case for recovery of costs from them. For the purpose of investment decision indirect benefits would remain important even in the latter case, because with limited investible resources net benefits of an irrigation work would have to be compared with net benefits of investment in alternative directions, and merely covering of costs would not be sufficient. Some investments are obviously more strategic than others in promoting economic development and suitable premiums must be attached to them.

If a project included at the margin has total benefit considerably greater than direct benefit, it will not be possible to recover the total cost from the direct beneficiaries though the undertaking of the project would be indicated. Even so, however, from the long-term point of view it would be appropriate to charge the direct beneficiaries below cost only when the indirect benefits do not emerge via the direct benefits. The value of agricultural produce, for instance, would be higher when a processing activity requires it than it would be in the absence of such a processing activity.

But in the short run an investment with large indirect benefits would be at a disadvantage compared to one with small indirect benefits, because indirect benefits would take time to make their impact. For this reason due regard must be given to the 'strategicity' of investment; investments with large indirect benefits being as a rule more strategic to economic development than those with less indirect benefits.

We have so far based ourselves on the assumption that the state must provide its services on a no-profit basis. But, at least at the present stage of our economic development when the state has to perform the function of the entrepreneur in many key sectors of the economy, it must like any other entrepreneur seek to augment its investible resources by earning profits on concerns run by it. On this basis there would be a strong case for making irrigation works, wherever possible, not only paying but also profitable, with indirect beneficiaries in their turn contributing through taxation and other charges it may be possible to levy on them.

Problems and delays in utilization of irrigation potential

Apart from the questions relating to remunerativeness of irrigation works, another set of questions relates to the problem of utilization of irrigation potentials created under the Plans. There have been serious shortfalls in this regard, as well as in the volume of construction. Under-utilization was particularly severe at the end of the First Plan and during the earlier years of the Second Plan, though since then the situation has greatly improved.[1]

At one stage strong pleas were made for downward revision of irrigation rates with a view to inducing more extensive use of water. With a given irrigation capacity having been created, it was argued, irrigation rates should be low enough to ensure fullest utilization of this capacity provided that avoidable working expenses were covered. The fact of the matter, however, is that expansion of irrigation depends upon a number of factors of which rates constitute only one. There are supply bottlenecks such as dearth of field channels; and fixation of outlets at right places is to some extent a matter of trial and error. On the demand side, cultivators take time to become accustomed to methods of wet cultivation, and the necessity of requisite changes in cropping patterns. And making available complementary resources such as draught power and fertilizers further lengthens the process. Through planned measures much can be done to shorten the time lag. But the planners seem to have made the extreme assumption that irrigation potential would be fully utilized as soon as it was created. There is also reason to believe that they even over-estimated the potentials created to a significant extent.

[1] This may be seen from the following table showing irrigation benefits from the First and Second Plan Schemes.

End of the year	*Potential at channel outlet (million acres)*	*Gross area irrigated*		*Net area irrigated (million acres)*
		in million acres	*as percentage of potential*	
1	2	3	4	5
1955–6	6·5	3·1	48	2·9
1956–7	7·4	4·2	58	3·4
1957–8	8·2	5·8	71	4·9
1958–9	9·7	6·5	67	5·9
1959–60	11·5	8·3	72	7·4
1960–1 (estimated)	13·2	10·0	76	9·0

Source: *Third Plan*, p. 382.

II. *Regions of Study—Variations in Conditions of Irrigation*

Punjab may be divided into three broad natural zones from the point of view of irrigation requirements. In the north and north-east, there are montane and submontane regions (in the foothills of the Himalayas). These areas receive relatively good rainfall during summer and moderately good rainfall during winter. The spring level here is quite high so as to permit extensive well irrigation on an economic basis. The central parts of the state constitute a riverain tract with high spring level—higher than in the north. These parts are most suited for irrigation from minor works—masonry wells and tube-wells, and canal irrigation requires to be minimized here for fear of waterlogging. The south and south-west of Punjab constitute a semi-desert tract with very little rainfall and so low a spring level that lift irrigation is almost entirely ruled out. Here prosperity of agriculture is entirely dependent on canal irrigation.

The Bhakra Project, undertaken in recent years, now provides the largest irrigation system of the country as a whole. The canals cut across practically the whole of Punjab and flow down into the adjoining state of Rajasthan. The bulk of the Bhakra water goes to irrigate the desert and semi-desert tracts of Punjab and Rajasthan, mainly the former. However, the Bhakra canals also serve the submontane and central tracts of the state. To the latter, because of its extensive facilities for minor irrigation, water is provided only during *rabi* (the season of winter crops). To the former in addition to *rabi* supplies some water is also provided for the *kharif* crops (during summer). The southern Punjab receives irrigation throughout the year. Accordingly the north-eastern, central and southern tracts are described as the restricted perennial, non-perennial and perennial zones (zones I, II and III) of the Bhakra canals.

In Punjab we conducted field investigations in the districts of Hissar, Karnal and Ludhiana. Hissar has benefited the most from Bhakra canals. Situated in the south-west of Punjab on the border of the state of Rajasthan, it forms part of the vast north-western Indian desert. The need for irrigation in the district has been great and it has been provided with the largest quota of water, on a perennial basis.

Karnal and Ludhiana both lie in the restricted perennial zone. However, they present quite diverse conditions. Karnal is in the southern part of this zone and has marked similarities with Hissar.

It has sandy soil, though rainfall conditions are better. A special problem in this district has been weed-infestation which has caused extensive areas of land in the district to become waste. Extensions of irrigation have thus been conditional on reclamation work. Facilities for minor irrigation in this district are not extensive.

Ludhiana, in contrast, has extensive facilities for minor irrigation. It is situated in the central parts of the state and although it does not lie in zone I of the Bhakra canals, which covers the central parts, it borders it and is broadly typical of the conditions prevalent in the riverain tract of central Punjab.

U.P. presents even more diverse physical conditions. In Punjab because of limited rainfall there has been need for irrigation more or less throughout the state. U.P., in contrast, has tracts receiving high rainfall and at the same time abounding in sources of minor irrigation. These conditions prevail towards the north-east. Thus, the question of providing state irrigation in these parts was simply not considered in the past, though in recent years extensive networks of state tube-wells as well as some state canals have been laid. At the same time, U.P. also has, in its western parts, tracts which possess conditions not very different from Punjab and where accordingly both state canals and tube-wells have long existed. Finally, U.P. has a southern tract in which rainfall is very uncertain and varies widely from year to year. Roughly, we may call this the region of medium rainfall, where normal rainfall is at a certain critical minimum that permits extensive cultivation in normal years but where any short fall below the normal causes widespread failure of crops. Moreover, this tract has very special soil conditions. In other parts of U.P. and in Punjab the need for irrigation is by and large a function of rainfall conditions—its extent and distribution. Soil variations do not affect the demand for irrigation very significantly. In Punjab and Western U.P., rainfall is limited and there is need for irrigation almost all the year round. In eastern U.P. rainfall is high but its distribution is not entirely satisfactory. There is little need for *kharif* irrigation except in abnormal years. Indeed in this part of the year floods are often the problem. However, winter rains are very limited and *rabi* crops almost invariably require irrigation. In southern U.P., more familiarly known as the Bundelkhand region, need for irrigation is at least as dependent upon soil conditions as upon rainfall. There are four distinct types of soil in the region which, moreover, do not constitute distinct areas but have strips lying intermixed. These soil types are locally called

mar, *kabar*, *parwa* and *rankar*. The first is a variety of black cotton soil highly retentive of moisture and accordingly needing very little irrigation. *Kabar* is a mixture of *mar* and *parwa* while *parwa* is sandy loam in character and yellowish-red in colour. *Rankar* is stony soil and permits little cultivation. In contrast to the *mar* soil, the *parwa* soil needs intense irrigation. *Kabar* also generally requires irrigation. The Bundelkhand region because of its uncertain rainfall is typically the region that is believed to require what is called 'protective' irrigation—irrigation which is not expected to be remunerative but is considered justifiable on grounds of providing protection against drought. The Betwa canal, which is being currently enlarged through the construction of the Mata Tila Dam, is the most important irrigation work of Bundelkhand and has been the oldest canal of the country constructed on the 'protective' basis. Southern parts of eastern U.P. and some of the areas in central U.P. bordering on Bundelkhand region (which is largely south-western U.P.) are not very different in physical conditions from the Bundelkhand region. Central U.P. as a whole may be considered as having mixed features of western and southern U.P.

The most important irrigation source is the Sarda canal which covers the entire tract of central U.P. It was constructed during the nineteen-twenties. Major extensions have been made to it under the Plans. Generally, the older canals in both U.P. and Punjab have their capacity fully utilized. But the Sarda canal has been an exception. Originally constructed on 'productive' grounds, it has on account of continuous under-utilization of potential proved to be non-remunerative. Of the districts in which our field investigations were conducted, Hardoi and Sitapur are served by the Sarda canal. In southern U.P., investigations were conducted in Jhansi and Allahabad districts, the former of which is fully characteristic of the Bundelkhand region while the latter is situated immediately north of Bundelkhand and presents a somewhat mixed situation between those prevalent in central U.P. and those prevalent in the extreme south of the state. In view of the long-standing importance of the Betwa canal as a protective irrigation work, a special study has been made of its finances.

In eastern U.P. state irrigation has come only in recent years, but it has come in a big way, and is of special interest in view of the abundance of rainfall as well as of private sources of irrigation. State irrigation has been provided there mainly through networks of tube-wells. In their effects such networks are not very different from canals. Tube-wells undoubtedly are minor works and are quite frequently

sunk by private individuals. However, it is only big cultivators who can afford to do this. A network of state tube-wells provides irrigation to a whole region which cannot be done through private tube-wells. Field investigations were conducted in the Gorakhpur district of eastern U.P. which permits the tracing out of irrigation developments in eastern U.P. over an appreciable period of time.

III. *Case Studies in Punjab*

Finances of the Bhakra canals

'In no other province are there greater facilities for extensive irrigation, in none is it more urgently necessary or more keenly appreciated' as in the Punjab.[1] Major works have always been constructed on 'productivity' considerations. Irrigation rates have been increased by only 50 per cent. over the pre-war rates notwithstanding the manifold rise in prices since, so that in real terms rates are much lower at present than in the past.[2] Construction cost per unit of irrigable area created is much higher in the case of Bhakra canals than for older canals partly because of price rises and partly because of greater real costs of high dams and long channels. It is interesting to note, however, that Bhakra canals were nevertheless expected to be made remunerative without any further increase in irrigation rates.[3]

[1] *Report of the Indian Irrigation Commission 1901–03, Part II—Provincial*, p. 1.

[2] Rates on the Bhakra canal are the same as on the Western Jumna and the Sirhind canals. As operative since 1949 when they were raised by 50 per cent. over the levels at which they had remained, except for minor adjustments, prior to that date throughout the present century, they are shown below. These are 'flow' rates chargeable on areas that can be irrigated through gravitational channels. Wherever water has to be lifted, rates are halved.

	Rs. per acre		*Rs. per acre*
1. Sugar-cane (except on *kharif* channels)	16·50	8. Wheat, barley and oats (except on *kharif* channels, maize, oilseeds)	6·37
2. Sugar-cane on *kharif* channels	13·50	9. Bajra, gram and pulses	4·87
3. Water nuts	11·25	10. Jowar, fodder including turnips, grass requiring more than one watering	3·75
4. Rice	9·75		
5. Cotton	6·75		
6. Dyes, tobacco, poppy, spices, gardens and orchards (per half year) and vegetables except turnips	8·25	11. All rabi crops on *kharif* channels	3·00
		12. Village and district board plantations, grass requiring one watering, watering for ploughing not followed by a crop, one watering in *rabi*	1·50
7. Melons, fibres (other than cotton), all crops not otherwise specified	7·50		

[3] The financial proposals and estimates are contained in the *1955 Project Report on Bhakra-Nangal* (mimeographed) of the Irrigation Department of the Government of Punjab, vol. i, pt. ii.

It was expected that Bhakra canals would become 'productive' in 1969–70, fifteen years after the opening of the main lines, yielding the required 4·25 per cent. of net rate of return on sum-at-charge and over and above that a small profit of about 9 lakhs of rupees.

In actual fact these calculations were upset on several scores during the first few years of functioning. There was failure in the collection of the betterment levy which after one year of collection of instalments (during 1958–9) had to be held in abeyance on account of widespread political agitation against it, notwithstanding the fact that the levy was ultimately imposed only on area actually irrigated and not on all area under command as was planned earlier. At present, fresh attempts are being made to collect instalments of the levy. As regards other charges, the position can be gauged from the table below:

TABLE 1. *Rate of returns from Bhakra canals 1954–5 to 1958–9*

Year	*Mean composite water rate assessed*		*Mean of enhanced land revenue per acre assessed (Rs.)*	*Mean of area assessed per cusec of mean discharge at head (acres)*
	Per acre assessed (Rs.)	*Per cusec of mean discharge at head (Rs.)*		
1	2	3	4	5
1954–5	2·35	429·27	0·32	182·35
1955–6	2·05	297·72	0·23	145·08
1956–7	2·53	685·66	0·25	152·61
1957–8	3·48	660·35	0·21	189·36
1958–9	2·51	527·90	0·11	210·55

Source: Administration Reports of the Irrigation Department of Punjab.

We thus find that per acre average yield from rates was only about half the anticipated rate. Enhancement in land revenue was nominal. Furthermore, the water supplied went to irrigate far less area than earlier anticipated. We accordingly have low figures in columns 3 and 5 which will be better appreciated if compared with corresponding averages obtained on other canals in the state. In Table 2 overall averages for the four-year period 1954–5 to 1957–8 for the more important Punjab canals including the Bhakra canals are given. This shows how water has been utilized inefficiently under the Bhakra canals.

There are strong reasons to believe that unfavourable conditions reflected in the above tables are essentially of a transitional nature. The small average of area irrigated per unit of discharge is partly due to high initial absorption losses in sandy tracts, which will diminish

in course of time, and partly due to lags in extension of irrigation. The small average yield per acre assessed is due to lack of crop-pattern changes in favour of high-rate-yielding crops, which changes may also be reasonably expected to come about in course of time.

The main error from which the financial estimates for the Bhakra canals suffer is insufficient allowance for the problems of the transitional phase. It was assumed that from the very beginning water would be used as efficiently as it has come to be used in course of time

TABLE 2. *Mean incidence of assessed water revenue during years 1954–5 to 1957–8*

Canal	*Mean composite water rates assessed*		*Mean of enhanced land revenue per acre assessed (Rs.)*	*Mean of area assessed per cusec of mean discharge at head (acres)*
	Per acre assessed (Rs.)	*Per cusec of mean discharge at head (Rs.)*		
1	2	3	4	5
I. *Productive canals*				
1. Western Jumna canal (inclusive of extensions)	6·39	2,124·45	0·46	332·61
2. Sirhind canal	5·71	1,959·69	0·14	342·85
3. Upper Bari Doab canal	5·70	1,941·52	0·74	340·19
4. Eastern canal	6·13	1,665·13	0·57	271·47
5. Shahnehar canal	6·98	958·54	0·50	137·25
6. Bhakra canals	2·59	430·79	0·25	166·60
II. *Unproductive canals*				
7. Ghaggar canal	6·39	1,006·94	0·52	157·44

Source: Administration Reports of the Irrigation Department of Punjab.

on the older canals, and that even the cropping pattern would be the same from the very beginning as it is on the older canals. Moreover, the water-rates policy was framed in such a way that irrigation was required to pay at much higher rates in the initial phases than ultimately, while in fact it should have been the other way round.

An important flaw in the long-term project estimates for the Bhakra canals also consists in the over-estimation of the irrigation potential.[1] This can be readily seen from Table 3 below, which gives official estimates on which the financial forecasts were based.

We thus find that entirely on the basis of assumptions made officially average supplies of water available would be about 25 per cent. less

[1] This aspect of the matter has already been emphasized by K. N. Raj in *Some Economic Aspects of the Bhakra Nangal Project*, pp. 52–54.

than required for meeting the commitments made. Indeed, even the maximum possible supply (net utilizable storage) is about 9 per cent. less than that required. Irrigable area obviously should have been calculated on the basis of average availability of supply.

TABLE 3. *Supplies of water required and available for irrigation from the Bhakra reservoir*

I. *Supplies required per annum on full development*

Irrigation zone	*Culturable commanded area (acres)*	*Intensity of irrigation (% of c.c.a.)*	*Irrigable area (acres)*	*Water allowance (at distributory head in cusecs per 1,000 acres of c.c.a.)*	*Supplies required to fulfil commitments indicated in columns 2 to 5* (million acre-feet)*	*Net supplies required from storage (the rest being available from the normal flow of the river (million acre-feet)*
1	2	3	4	5	6	7
1. Restricted perennial	1,588,599	45	714,780	2·25	1·534	1·888
2. Non-perennial	600,183	35	210,064	3·50	0·683	0·229
3. Perennial	3,672,798	62	2,277,135	2·75	6·148	3·838
4. Sirhind canal requirements (to improve water allowance and capacity factors on that canal)	Area benefited: 3,512,629	(increased only)	402,204	(increased only)	0·952	0·252
Total	5,861,580	..	3,604,273	..	9·317	6·207

* And capacity factors (not indicated here) laying down the various percentages of capacity at which the canals would flow in different parts of the year in different zones.

II. *Supplies available*

	In million acre feet
Gross capacity of the reservoir at maximum level of 1,680	7·400
Dead storage capacity corresponding to dead storage level of 1,440	1·675
Live storage capacity losses in reservoir due to evaporation, &c.	0·100
Net utilizable storage	5·625
Mean supplies available (based on analysis of discharge data of the River Sutlej for the period *1928 to 1947*)	4·631

Source: 1955 Project Report on Bhakra Nangal of the Irrigation Department of Punjab.

Irrigation development under the Bhakra canals in selected districts

The deficiency of water supply mentioned above will be met only on full development of the Bhakra canals which was originally

expected to be achieved by 1962–3 but may now come about somewhat later due to construction delays. Our study refers only to the period when the commitments under the Bhakra canals were yet to reach their maximum level. However, the estimates made of irrigation potentials even for this transitional phase involved considerable overestimation. In the first place, the potential is estimated simply on the basis of water supplies made available in government channels which do not include the final channels from outlets to fields, called watercourses, which remain the responsibility of the cultivators. This enables the irrigation authorities to claim that water has been brought to a given area without ensuring that water can in fact reach the entire area in question. There are many difficulties in construction of watercourses. In any case they are constructed only in course of time. Quite frequently there are impediments which cannot be readily removed by the cultivators, and government channels themselves may ultimately be found insufficient, and the outlets provided on them may have been fixed at inappropriate places. Indeed, this is the most frequent complaint.

Secondly, in sandy tracts absorption losses are much higher during initial years of irrigation than later when soil becomes somewhat hardened. There is thus need for estimating the irrigable area in such regions at a lower level during the initial years. In the Hissar district almost the only complaint of cultivators was that water allowance for absorption was insufficient. It is difficult to explain the reported under-utilization of the Bhakra potential in Hissar district, where the demand has been very high. Probably, the explanation is that the estimate of the potential has been inflated and the area claimed to be irrigable is not in fact irrigable in the present circumstances.

Irrigation development in the Hissar district under the Bhakra Project is brought out in Table 4 below.

Bhakra water has also been utilized for strengthening the older canals. It is thus that we find some expansion in irrigable area between 1948–9 and 1953–4 which is prior to the opening of the Bhakra main lines in 1954–5. On an overall basis one finds more than full utilization of potential in the district. On the other hand, considerable under-utilization is reported in case of the Bhakra main lines, which becomes particularly severe in 1958–9. The estimate of the capacity of the older canals, in particular the Western Jumna canal which was the most important source of irrigation in the district in the past, requires to be revised in the upward direction in the light

TABLE 4. *Irrigation development in Hissar district*

Total area = 3,432,215 acres. Cultivable area = 3,283,500 acres. Cultivated area = 3,080,845 acres.

	Bhakra main lines					*All canals*				*Rainfall in the region served by the Western Jumna canal (inches)*
			Irrigated area					*Irrigated area*		
Year	*Culturable commanded area (acres)*	*Irrigable area (acres)*	*in acres*	*as % of irrigable area*	*Rainfall (inches)*	*Culturable commanded area (acres)*	*Irrigable area (acres)*	*in acres*	*as % of irrigable area*	
1	2	3	4	5	6	7	8	9	10	11
1944–5	..	..	..	..	..	747,358	326,267	336,970	103·3	15·68
1948–9	..	..	..	..	..	747,358	326,267	345,841	106·0	14·86
1952–3	..	..	..	..	..	992,798	429,833	534,862	124·4	16·73
1953–4	..	..	..	..	..	988,239	413,507	550,918	132·2	22·14
1954–5	1,242,462	310,615	125,151	40·3	N.A.	2,230,587	724,068	847,636	117·1	17·20
1955–6	1,249,927	312,482	250,411	80·1	26·31	2,219,642	723,698	992,019	137·1	24·61
1956–7	1,255,496	314,338	181,765	50·3	21·61	2,265,578	784,400	935,678	125·0	21·54
1957–8	1,255,103	353,773	262,724	74·3	14·73	2,316,557	865,527	1,084,927	125·3	24·61
1958–9	1,255,103	778,164	369,817	47·5	23·26	2,309,685	1,282,362	1,234,865	96·3	20·92

Source: Administration Reports of the Irrigation Department of Punjab.

of experience, but such revision has not been made. On the other hand, Bhakra main lines have been prematurely credited with too high potentials. It was originally projected that by 1958–9 channels would become perennial. However, even so, in view of the fact that the construction was not to be entirely completed by this year intensity of irrigation in the perennial zone was to be put at 45 per cent. and not at 62 per cent. which was to be the intensity in this zone on ultimate development by 1962. In view of construction delays channels could not become perennial by 1958–9. However, one finds the irrigable area for the Hissar district under the Bhakra main lines calculated at full 62 per cent. in 1958–9.

It can also be seen from Table 4 that variations in the extent of irrigation have not been inversely related to variations in the extent of rainfall. Indeed at times increased rainfall has been coupled with increased irrigation. This can be readily seen by comparing 1955–6, a year of high rainfall, with the following year, 1956–7, when rainfall was considerably lower. A study of irrigation performance under the Western Jumna canal brings out a similar relationship. It is obvious that not only the extent of rainfall but also its distribution over different parts of the year is important in determining the extent of irrigation. However, in a sandy tract such as Hissar even a positive correlation between extent of rainfall and extent of irrigation is not ruled out *a priori*. Indeed such a relationship is likely wherever demand for irrigation generally exceeds supply. In a year of high rainfall a given quantum of water supplied through the canal (this quantum itself increases in such a year) suffices for irrigating a larger area than in a year of low rainfall. With supply of water as the bottleneck, irrigation would be more extensive in the former than in the latter year.

Irrigation developments under the Bhakra Project in Karnal and Ludhiana districts are brought out in Tables 5 and 6 respectively.

In both Karnal and Ludhiana districts the estimate of the Bhakra potential was revised downwards in a marked degree in 1957–8. We thus have official recognition of the fact that at least during the first three years the potentials for these districts were over-estimated.

Unlike Hissar, where irrigation under the Bhakra main lines started from a substantial level and though generally rising also suffered a marked fall in one of the years (1956–7), in Karnal and Ludhiana, more specially the former, expansion of irrigation from these canals has been continuous and steady. In Karnal, area under

TABLE 5. *Irrigation development in the Karnal district*

Total area = 1,975,033. Culturable area = 1,725,417. Cultivated area = 1,387,366.

	Bhakra main line					*All canals*				*Rainfall in the region served by the Western Jumna canal (inches)*
			Irrigated area					*Irrigated area*		
Year	*Culturable commanded area (acres)*	*Irrigable area (acres)*	*in acres*	*as % of irrigable area*	*Rainfall (inches)*	*Culturable commanded area (acres)*	*Irrigable area (acres)*	*in acres*	*as % of irrigable area*	
1	2	3	4	5	6	7	8	9	10	11
1945–6	..	..	..	..	..	781,012	315,636	307,144	97·3	26·82
1948–9	..	..	..	..	..	781,012	315,636	262,884	83·3	29·99
1951–2	..	..	..	..	..	781,012	315,636	345,552	109·5	17·61
1952–3	..	..	..	..	..	781,012	315,636	340,729	107·9	29·15
1953–4	..	..	..	..	..	782,477	316,368	325,760	102·9	32·98
1954–5	231,848	104,332	8,660	8·3	N.A.	1,013,727	412,630	429,971	104·2	19·51
1955–6	231,616	104,228	15,308	14·7	N.A.	1,027,644	415,220	385,115	92·7	35·58
1956–7	247,075	110,724	29,327	26·5	N.A.	1,049,270	380,921	422,090	110·8	34·87
1957–8	247,366	79,645	53,402	67·1	N.A.	1,064,782	393,612	478,444	121·6	24·92
1958–9	247,366	99,762	72,955	73·1	N.A.	1,065,844	437,982	475,043	108·5	37·63

Source: Administration Reports of the Irrigation Department in Punjab.

TABLE 6. *Irrigation development in the Ludhiana district*

Total area = 846,699 acres. Culturable area = 757,905 acres. Cultivated area = 686,328 acres.

	Bhakra main line					*All canals*				*Rainfall in the region served by the Sirhind canal (inches)*
			Irrigated area					*Irrigated area*		
Year	*Cultivable commanded area (acres)*	*Irrigable area (acres)*	*in acres*	*as % of irrigable area*	*Rainfall (inches)*	*Cultivable commanded area (acres)*	*Irrigable area (acres)*	*in acres*	*as % of irrigable area*	
1	2	3	4	5	6	7	8	9	10	11
1945–6	..	..	..	..	..	229,465	61,307	125,151	204·1	37·28
1948–9	..	..	..	..	..	229,465	61,307	123,985	202·2	17·38
1951–2	..	..	..	..	..	N.A.	N.A.	103,283	..	18·61
1952–3	..	..	..	..	..	301,260	111,033	114,659	103·3	17·02
1953–4	..	..	..	..	..	305,716	113,707	121,573	106·9	21·43
1954–5	128,175	59,524	17,465	29·3	31·39	466,370	174,870	138,261	79·1	22·57
1955–6	128,175	59,524	20,403	34·3	65·91	466,372	174,870	138,868	79·4	47·20
1956–7	135,628	61,033	21,681	35·5	33·66	482,677	188,029	147,616	78·5	25·54
1957–8	130,907	45,817	31,632	69·0	21·45	478,171	172,909	156,262	90·4	24·21
1958–9	130,902	52,363	30,464	58·2	30·80	478,261	179,455	144,977	80·8	33·93

Source: Administration Reports of the Irrigation Department of Punjab.

Bhakra irrigation starts from a fairly low level to rise to quite a substantial level by 1958–9. In Ludhiana the start was more substantial but progress less marked. In Karnal the bottleneck has been the pace of reclamation work which has been simultaneously progressing and upon which expansion of irrigation in the district has to an important extent been dependent. In Ludhiana sources of minor irrigation have been extensive, and these have been competing with the canal supplies. Thus, between the three districts studied, the utilization of the Bhakra potential has been the least in Ludhiana.

Table 7 gives information regarding irrigation from various sources during 1958–9 in six villages of Ludhiana district where we had conducted field investigations.

TABLE 7. *Irrigation from all sources in the sampled villages of the Ludhiana district 1958–9*

Name of the village	*Cultivated area (acres)*	*Canal potential (acres)*	*Canal irrigated area (acres)*	*Degree of utilization (col. 4 as % of col. 3)*	*Number of masonry wells*	*Number of private tube-wells*	*Irrigated area from all sources*	
							in acres	*as % of cul. area*
1	2	3	4	5	6	7	8	9
Rattan Heri . .	606	233	231	99·1	25	1	248	40·9
Lohar Majra Kalan	1,124	494	285*	92·8†	45	1	464	41·3
Barwati Kalan .	888	351	157	44·7	42	3	494	55·6
Barwati Khurd .	771	313	129	41·2	20	1	354	45·9
Manupar . .	1,645	644	219	34·0	70	5	1,016	67·9
Ramgarh . .	402	169	52	30·8	22	3	330	82·9

* Rabi area only. † Degree of utilization of *rabi* potential only.

Source: Village records and spot inquiries.

The villages have been arranged in descending order according to the degree of utilization of canal potential. It is interesting to note that the low utilization villages are not less irrigated on the whole. If at all it is the other way round. We thus have a clear indication of effective competitiveness of private sources of irrigation with state canals. However, it must also be noted that high-utilization villages are not without private sources of irrigation. Rattan Heri, for instance, where most of the irrigated area was canal-irrigated, has as many as twenty-five masonry wells and one tube-well, which obviously were very much under-utilized, indeed were hardly in use. This suggests

that wherever canal irrigation got a foothold it tended to oust private sources of irrigation. Canal irrigation was generally found to be much cheaper, which was of decisive significance in case of high water-consuming crops such as sugar-cane and paddy.

While the cultivators everywhere emphasized only the supply bottlenecks, it was clear that the intensity of demand for state irrigation also varied considerably from one district to another, depending largely on the availability of alternative sources.

IV. *Case Studies in U.P.*

Finances of the Sarda canal and problems of irrigation development under it

State irrigation in U.P. has also been highly remunerative though not quite as remunerative as in Punjab.[1] However, unlike Punjab, where almost all irrigation has been provided on productivity considerations, there are large areas in U.P. where major irrigation schemes have been taken in hand on considerations other than remunerativeness. Overall profitability of state irrigation is almost entirely due to the four oldest canals which have large irrigation capacities but very low capital costs, having been constructed at a time when prices were very low. In southern U.P. the principle of subsidizing irrigation is fully established, and this has led to fixation of rates at considerably lower levels than in other parts of the state. Elsewhere, state irrigation in principle requires to be remunerative, but none of the works constructed in the present century has in fact proved to be so.

In case of the Sarda canal, which was originally constructed on productivity considerations, the project estimates went wrong, essentially because of continuous under-utilization of the canal's irrigation capacity as officially estimated. The irrigation performance and also the financial results of the Sarda canal since its opening in 1928 are brought out in Table 8. Net revenue (revenue after meeting working expenses but not interest charges) is not entirely a function of the area under irrigation. A good deal also depends on the crop pattern on this

[1] By 1947–8 accumulated surpluses (over working expenses and interest charges) earned on profit-yielding works had exceeded accumulated arrears of interest due to loss-yielding works by Rs. 21·55 crores. Notwithstanding rapid increases in capital outlay in later years, which greatly inflated interest charges but on which full fruits remained to be reaped, state irrigation works on an over-all basis continued to yield surpluses during most of the years till 1955–6. There were, however, large over-all deficits during 1956–7 and 1957–8 by which time investment in irrigation had greatly increased.

area (charges for different crops being highly varied). Even working expenses vary appreciably from year to year affecting the level of net revenue. However, it can be seen that from 1938–9 onwards, that is after ten years of the functioning of the canal, net revenues are relatively large. Utilization of potential has varied from roughly half to three-quarters. If there were full or near- full utilization, revenues would have been correspondingly higher.

Table 8 also suggests some of the possible causes of under-utilization. In particular, it is significant to note that even during periods over which the irrigable area remained constant length of channels increased substantially. Between 1931–2 and 1943–4 increase in irrigable area was nominal, merely 0·7 per cent. Increase in length of channels in the same period was 13 per cent. In later years also irrigable area has increased in jumps while length of channels has increased steadily and continuously. It is thus obvious that there have been considerable lags in channel construction which have not been duly allowed for in estimating the annual potentials. Table 8 is also indicative of the time-consuming nature of irrigation development. This is partly, but not entirely, due to lags in channel construction. There was also inefficient utilization of water under the Sarda canal as compared with water utilization from the older canals.

The suggestions thrown up by the data presented above received strong supporting evidence from our field investigations conducted in selected villages of Hardoi and Sitapur districts, which among all districts served by the Sarda canal were found to be most subject to under-utilization of the canal's potential. Within these districts we selected three sets of two villages each in such a manner that one village in each of these sets was a low-utilization village and the other a neighbouring village with as far as possible similar conditions but showing a comparatively high degree of utilization. In one set degrees of utilization were 9 per cent. and 300 per cent., in another set 20 per cent. and 105 per cent. and in the third set 13 per cent. and 76 per cent. (all during 1958–9). Cultivators in the low-utilization villages invariably pointed to one or another difficulty which caused large areas in their villages to be in fact inaccessible to water though officially included within the command of the canal. These difficulties included lack of channels, existence of drains in between the outlets provided and the areas supposed to be served, inappropriate positions of outlets, paths taken by the channels in a manner as to exclude large areas from being gravitationally accessible, and so on. Since high and low utilization

villages were selected in close proximity in each of the sets, it is difficult to explain the variations in the degree of utilization in terms of physical variations or even subjective variations. The cultivators in

TABLE 8. *Sarda canal—financial results and irrigation performance*

Year	Capital invested to the end of the year with accumulated arrears of interest (Rs. crores)	Length of channels (miles)	Irrigable area (lakhs of acres)	Irrigated		Annual rainfall (inches)	Gross revenue (Rs. lakhs)	Working expenses (Rs. lakhs)	Net revenue (Rs. lakhs)	Percentage of net revenue on capital invested
				in lakhs of acres	as % of irrigable area					
1	2	3	4	5	6	7	8	9	10	11
1928–9	10·11	2,953	12·77	3·35	26·2	26·84	0·02	..	+0·02	+0·00
1929–30	11·41	3,573	15·98	6·00	37·6	35·63	13·12	12·42	+0·70	+0·06
1930–1	12·36	3,892	13·50	5·39	39·9	34·88	17·64	20·12	−2·48	−0·20
1931–2	13·07	4,154	15·43	6·00	38·9	42·86	15·92	17·93	−2·01	−0·15
1932–3	13·52	4,177	15·43	8·52	55·2	26·39	39·02	19·68	+11·35	+0·84
1933–4	13·94	4,193	15·43	7·56	49·0	39·57	29·57	22·90	+6·67	+0·48
1934–5	14·36	4,232	15·43	7·37	47·8	37·90	24·37	21·64	+2·74	+0·19
1935–6	14·64	4,265	15·43	10·14	67·4	26·74	40·60	23·96	+16·64	+1·14
1936–7	14·90	4,273	15·49	6·53	42·1	70·97	41·71	25·06	+16·65	+1·12
1937–8	15·26	4,276	15·49	10·13	65·4	26·41	29·51	21·79	+7·72	+0·51
1938–9	15·50	4,277	15·49	8·52	55·0	49·14	39·25	18·14	+21·10	+1·36
1939–40	15·75	4,282	15·49	9·12	58·9	32·59	42·00	19·86	+22·14	+1·40
1940–1	16·03	4,342	15·54	9·03	58·1	31·44	45·89	19·40	+26·49	+1·65
1941–2	16·39	4,612	15·54	11·99	77·1	24·79	45·12	20·29	+24·83	+1·52
1942–3	16·51	4,628	15·54	11·53	74·2	36·25	60·49	22·44	+38·05	+2·30
1943–4	16·71	4,702	15·54	10·40	66·9	42·54	58·02	26·81	+31·21	+1·87
1944–5	16·95	4,841	17·11	10·16	59·4	29·01	60·55	32·17	+28·38	+1·67
1945–6	17·22	5,117	17·11	11·99	69·8	34·42	67·37	37·52	+29·84	+1·73
1946–7	17·55	5,335	17·11	12·06	70·5	29·71	74·37	45·56	+28·81	+1·64
1947–8	17·91	5,573	19·68	10·63	54·0	35·42	77·53	46·70	+27·83	+1·55
1948–9	18·46	5,552	19·68	10·92	55·6	43·76	66·69	57·12	+9·57	+0·52
1949–50	18·90	5,705	19·71	8·09	41·0	N.A.	82·07	51·19	+30·88	+2·65
1950–1	19·27	5,818	19·71	12·97	65·8	N.A.	117·63	63·76	+53·87	+4·30
1951–2	19·46	5,904	18·66	14·33	76·8	22·56	104·70	69·27	+45·42	+2·33
1952–3	19·81	6,115	18·66	14·56	78·0	31·34	129·94	65·66	+64·28	+3·24
1953–4	19·53	6,440	18·81	11·89	63·2	45·74	140·02	57·44	+82·58	+4·22
1954–5	20·24	6,540	18·87	10·99	58·2	37·13	155·98	49·15	+106·83	+5·27
1955–6	24·81	6,808	18·87	9·53	50·6	52·40	139·65	68·41	+71·23	+2·87
1956–7	25·83	7,013	19·48	10·77	55·3	35·10	140·25	82·43	+57·82	+2·24
1957–8	26·90	7,404	19·48	13·00	66·7	32·79	141·96	104·70	+37·26	+1·38

Source: Administration Reports of Irrigation Department, U.P.

the low-utilization villages were found to be only too jealous of those in the high-utilization villages, and it was not possible to suppose that there was lack of demand or consumer resistance on the part of the former. The conclusion was inescapable that sizeable parts of the

areas supposed to be covered by the Sarda canal were not in fact covered by it.

The Betwa canal in the Bundelkhand region—a case study in 'protective' irrigation

The Betwa canal is the oldest and the most important canal of the Bundelkhand region (southern U.P.), where irrigation has been provided on 'protective' basis and where accordingly irrigation charges have been kept lower than their general level in the state. Major extensions to the canal will presently be under way with the construction of the Mata Tila dam on the Betwa river, which is scheduled to be completed under the Third Plan and is expected to provide, on full development, additional irrigation on 4·13 lakhs of acres. This dam is being built up as the most important source of supply of irrigation in the Bundelkhand region. It will not only be used to strengthen the supplies of the Betwa canal but also of a number of other canals in the region (Table 9).

One finds considerable year-to-year variations in the degree of utilization of this canal's potential. However, one can also discern fairly clearly a long-term trend for the degree of utilization to achieve a high level on a stable basis. Thus during the quinquennium 1928–9 to 1932–3 the degree of utilization is found to range between 35·2 per cent. and 110 per cent. During the next twelve years, 1933–4 to 1944–5, it ranges between 69·4 per cent. and 94·7 per cent., except for one year (1936–7) when it was exceptionally low at 48·8 per cent. It is specially significant that there have not been any serious lags in the utilization of additional capacity created in recent years. However, this state of irrigation development has been reached in the course of a fairly long period of time. The slow rate of irrigation development under this canal has been a major factor in causing the large financial deficits which have been suffered on its account. Though the Betwa canal was sanctioned as a 'protective' work it was nevertheless anticipated to yield 3·34 per cent. return on capital outlay which was only a little less than the 4 per cent. return then required under the productivity criterion.[1] However, during the first eight years of its existence the Betwa canal irrigated no more than 40 per cent. of the area that it was anticipated to irrigate during this period. This had already completely upset the financial forecast at the time the completion report of the canal was being drafted, and this notwithstanding

[1] *Report on the Closing of the Construction Estimates, Betwa Canal,* 1896, p. 6, para. 12.

the fact that the working expenses during these initial years had turned out to be considerably less than anticipated.[1] Irrigation expansion since then has gathered momentum only gradually. During the post-

TABLE 9. *Betwa canal—financial results and irrigation performance*

Year	Capital invested to the end of the year with accumulated arrears of interest (Rs. crores)	Length of channels (miles)	Irrigable area (lakhs of acres)	Irrigated area		Annual rainfall (inches)	Gross revenue (Rs. lakhs)	Working expenses (Rs. lakhs)	Net revenue (Rs. lakhs)	Percentage of net revenue on capital invested
				in lakhs of acres	as % of irrigable area					
1	2	3	4	5	6	7	8	9	10	11
1928–9	1·78	735	1·77	1·63	92·0	21·36	1·62	2·94	−1·32	−0·75
1929–30	1·79	735	1·77	1·95	110·0	22·79	5·27	3·22	+2·04	+1·14
1930–1	1·80	737	1·77	0·62	35·2	33·37	5·62	3·66	+1·95	+1·09
1931–2	1·82	773	1·77	0·82	46·5	30·86	2·44	2·65	−0·20	−0·11
1932–3	1·85	737	1·77	1·18	66·7	24·62	2·69	2·54	+0·15	+0·08
1933–4	1·86	742	1·77	1·23	69·4	30·08	4·64	2·94	+1·69	+0·91
1934–5	1·88	747	1·77	1·34	75·5	42·45	4·69	3·42	+1·26	+0·67
1935–6	1·88	754	1·77	1·66	94·0	27·51	6·02	3·08	+2·94	+1·56
1936–7	1·88	748	1·77	0·86	48·4	39·46	5·98	3·02	+2·96	+1·57
1937–8	1·90	748	1·77	1·45	81·8	30·69	3·28	2·74	+0·54	+0·28
1938–9	1·91	767	1·77	1·50	84·5	33·79	5·42	3·00	+2·42	+1·27
1939–40	1·91	772	1·77	1·62	91·8	31·43	5·88	2·85	+3·04	+1·59
1940–1	1·90	774	1·77	1·25	70·4	30·25	6·34	3·08	+3·26	+1·71
1941–2	1·91	774	1·77	1·58	89·3	19·92	5·40	2·92	+2·48	+1·30
1942–3	1·91	776	1·77	1·68	94·7	42·46	4·89	2·57	+2·32	+1·21
1943–4	1·91	786	2·06	1·64	79·5	32·24	6·27	3·06	+3·20	+1·67
1944–5	1·92	810	2·06	1·48	71·9	31·35	5·72	3·49	+2·24	+1·11
1945–6	1·96	812	2·07	1·76	85·4	25·85	6·42	4·61	+1·81	+0·90
1946–7	1·99	812	2·06	2·00	97·0	28·00	7·98	6·14	+1·84	+0·92
1947–8	2·09	827	2·06	1·69	82·0	39·00	7·78	8·51	−0·74	−0·35
1948–9	2·27	863	2·06	1·91	92·8	44·10	5·27	10·06	−4·79	−2·11
1949–50	Not available									
1950–1										
1951–2	2·55	1,079	2·06	1·90	92·3	35·40	12·14	9·97	+2·16	+0·84
1952–3	2·69	1,101	2·06	1·97	95·4	36·07	10·02	12·92	−2·90	−1·07
1953–4	2·76	1,101	2·06	2·07	100·3	29·30	10·83	7·10	+3·73	+1·34
1954–5	2·73	1,116	2·21	1·94	87·6	37·83	25·32	8·53	+16·79	+6·14
1955–6	11·32	1,152	2·21	2·11	95·3	34·04	21·47	16·76	+4·72	+0·42
1956–7	11·79	1,174	2·75	2·25	81·7	39·00	18·92	16·16	+2·76	+0·23
1957–8	12·11	1,201	2·75	2·82	102·3	33·50	19·86	18·94	+0·92	+0·07

Source: Administration Reports of the Irrigation Department of U.P.

war years gross revenue has increased greatly because of revisions in irrigation rates, but it has hardly caught up with the rise in working expenses with the result that net revenue has remained more or less where it was previously. Moreover, in the meantime the level of investment has gone up considerably without yielding anywhere near

[1] *Report on the Closing of the Construction Estimates, Betwa Canal,* 1896.

a proportionate increase in irrigable area, so that the rate of return in the more recent years has tended to become simply negligible. With the existing irrigation rates, which in spite of revisions have tended to lag behind prices, any marked improvement in the financial returns of the Betwa canal cannot be expected in the future.

The deficits of the Betwa canal have partly been due to the lower charges for irrigation in the region served by this canal as compared with the general level of charges in the state of U.P. It would thus be of interest at this stage to inquire as to how far the unremunerativeness of state irrigation in this region may be due to the lower charges here and how far it may be a part of the more general problem of making new irrigation pay for itself in the state as a whole. The Mata Tila dam is expected to cost on its irrigation side Rs. 12·83 crores on completion when its irrigation capacity will be 4·13 lakhs of acres.[1] Assuming 90 per cent. utilization of this potential on average, the capital cost per irrigated acre would work out to Rs. 345. Accordingly, to yield 4·5 per cent. return on capital as is the present requirement under the productivity criterion, an irrigated acre would on average be required to yield Rs. 15·53 by way of net revenue. Average working expenses in recent years have been around Rs. 7 to Rs. 8 per acre. Assuming that this will continue to be so, gross yield of revenue will on average need to be about Rs. 23 per acre. Gross returns have actually averaged Rs. 8 to Rs. 10 in recent years which may be compared with a yield of Rs. 13 to Rs. 14 in the same year by the Sarda canal on which the general schedule of rates applies. We thus find that the raising of rates in the Bundelkhand region to their general level in the state will suffice to meet only a small though substantial part of the likely deficit on account of new irrigation in this region.

The field investigations brought out the marked relationship between irrigated acreage on the one hand and soil conditions and cropping patterns on the other.

Comparing the villages Medki and Dhawakar, which are situated in close proximity, one finds the predominantly *mar* village, Dhawakar, utilizing its potential extremely poorly. However, between the villages Bakuwan and Simiria, which are another set of neighbouring villages, the former is found to be utilizing its potential relatively well although the *mar* area in the village does not form a much smaller proportion of total area than it does in the latter village which has utilized its potential very poorly.

[1] *Third Five-Year Plan*, annexure iv to chap. xxiv, p. 413.

However, though the existence of large *mar* areas may not *per se* be responsible for severe under-utilization, they may well impede irrigation development indirectly if they happen to be so situated as to block the flow of water from channels to irrigation-requiring *parwa* and *kabar* soils. Those parts of the region which had reported severe under-utilization were generally found to be areas of new irrigation, so that in part at least their under-utilization is likely to be due simply to the usual initial lags. At the same time, however, we found that channels in these areas flowed in such a manner that they had *mar* areas concentrated in their immediate neighbourhood with *parwa* and *kabar* areas lying largely across the *mar* areas. Gravitational canals cannot, of course, be run at will and it may be necessary from the engineering point of view to let them pass through *mar* areas. However, it would be necessary in such a case to construct appropriate channels out of the canal connecting it with the irrigation-requiring soils across the *mar* areas. The irrigation department considers itself only partially responsible for channel construction, while on private account the digging of final water-courses which lead up to the fields are quite problematic in any case and are specially so when they must pass through areas that themselves do not require irrigation.

Irrigation in these areas is mainly practised for wheat. More profound changes in cropping pattern, such as cultivation of sugar-cane and paddy, have hardly come about in this region, primarily because channels so far have not been perennial but have only been flowing during *rabi*, making only surplus supplies, if any, available for *kharif*.

It appeared that a high and stable demand for irrigation (except possibly on the *mar* soil) was as much to be expected in this region as anywhere else, provided only that cultivation here did not stagnate but progressed and prospered. The policy of 'protective' irrigation aims only at maintaining the traditional level of cultivation, which has been backward. It is little wonder in these circumstances that irrigation development has been very limited and extremely slow. In fact any rationale for 'protective' irrigation in this region can arise only from the supply side, viz. when water supplies are so limited that it is considered advisable to protect existing cultivation through as thin a distribution of water over as large an area as possible. At least with the construction of the Mata Tila dam such a situation seems to be reaching its end. Intensities of irrigation are being stepped up and

supplies are being planned on a perennial basis. Indeed, in view of these circumstances, it was proposed to raise the level of rates in the region to the general level in the state,[1] though this proposal was not ultimately implemented.

State tube-wells in the Gorakhpur district of eastern U.P.

Average rainfall in the Gorakhpur district averages around 50 inches, but is subject to wide variation. More importantly, most of the rainfall is concentrated from June to September. In these circumstances *kharif* crops, including such water-consuming crops as paddy, are normally grown on a rain-fed basis. *Rabi* crops, on the other hand, have almost invariably to be irrigated. Facilities of minor irrigation—non-masonry well involving little or no capital cost—have been extensive. Also, the labour employed in their construction is generally surplus family labour which has little or no opportunity cost. These wells are serviceable for only one season.

However, the traditional facilities of irrigation are extensive only. They are by no means efficient. Water is available at a high level but in very limited quantities. For more abundant supplies it is necessary to go so deep that traditional means are ruled out. Because of low yields of wells, some of the technically more efficient methods of well irrigation, such as the use of Persian wheels and animal power, are not economical and are seldom used. Indeed, the techniques of irrigation traditionally pursued in the Gorakhpur district have been of the most primitive variety, involving (*a*) high working expenses which for certain purposes are quite prohibitive, and (*b*) very superficial sprinkling of water over crops barely permitting them to be produced, without scope for improvement of yields.

In these circumstances, state tube-wells have definitely opened up new vistas and it was widely reported that yields of tube-well irrigated crops were significantly higher than of crops irrigated through traditional means. However, any marked increase in complementary inputs, such as fertilizers and manures, was not then reported. Similarly, it was found that while certain significant crop pattern development were taking place in the wake of tube-well irrigation, their pace was slow as they depended upon other factors as well.

State tube-wells in the Gorakhpur district are organized in five groups. Group-wise irrigation performance during 1958–9 is shown in Table 10.

[1] *Project of Mata Tila Reservoir on Betwa River*, 1951, p. 9, para. 47.

TABLE 10. *Performance of state tube-wells in Gorakhpur, 1958–9*

Name of group	*No. of tube-wells in operation on 31.3.'58*	*Earliest tube-wells energized in*	*Cultivable commanded area (acres)*	*Irrigable area (acres)*	*Irrigated area (acres) and assessment of rates (Rs.)*					
						Sugar-cane	*Other kharif*	*Rabi*	*Sugar-cane in rabi*	*Total*
1	2	3	4	5		6	7	8	9	10
Sardarnagar	28	1950	28,845 (1,030·2)	14,392 (514·0)	A	2,176 (29·3)	952 (12·8)	3,617 (48·8)	668 (9·0)	7,413 (51·5)
					R	61,651·49	14,337·24	24,563·99	8,076·13	108,628·85
					$\bar{R}$	28·32	15·06	6·79	12·09	14·65
Gorakhpur	61	1953	71,627 (1,174·2)	35,813 (587·1)	A	3,988 (25·3)	1,334 (8·5)	9,169 (58·3)	1,244 (7·9)	15,735 (43·9)
					R	104,845·14	15,722·36	50,778·86	12,868·84	184,215·20
					$\bar{R}$	26·29	11·78	5·54	10·34	11·71
Bansgaon	61	1954	101,540 (1,664·6)	50,770 (832·3)	A	988 (9·6)	172 (1·7)	8,732 (85·1)	371 (3·6)	10,263 (20·2)
					R	29,275·09	4,453·76	45,852·26	3,664·49	83,245·60
					$\bar{R}$	29·63	25·89	5·25	9·88	8·11
Pharenda	8	1954	8,677 (1,084·6)	4,338 (542·2)	A	369 (28·6)	36 (2·8)	684 (52·9)	203 (15·7)	1,292 (29·8)
					R	8,453·58	459·45	3,417·88	1,718·93	14,049·84
					$\bar{R}$	22·91	12·76	5·00	8·47	10·87
Maharajganj	3	1955	3,620 (1,206·7)	1,811 (603·7)	A	334 (44·8)	44 (5·9)	257 (34·4)	111 (14·9)	746 (41·2)
					R	8,716·49	506·46	1,545·17	1,315·24	12,083·36
					$\bar{R}$	26·10	11·51	6·01	11·85	16·20
All groups	161	1950	214,309 (1,331·1)	107,124 (665·4)	A	7,855 (22·2)	2,538 (7·2)	22,459 (63·3)	2,597 (7·3)	35,449 (33·09)
					R	212,941·79	35,479·27	126,158·16	27,643·63	402,222·85
					$\bar{R}$	27·11	13·98	5·62	10·64	11·35

Note. (1) Figures in brackets indicate in col. 4, c.c.a. per tube-well; in col. 5, irrigable area per tube-well; in col. 6 through 9, percentages of irrigated areas under respective heads to total irrigated area; in col. 10, percentage of irrigated area to irrigable area.

(2) Under columns 6 through 10, row A indicates irrigated area, row R assessment of rates and row $\bar{R}$ average assessment per acre.

(3) As on canal, so also on tube-wells, a rebate of 19 *naye paise* per rupee was being allowed in 1958–9. The actual returns would thus fall short of assessment by 19 per cent. Tube-well water is assessed at the rate of 1,600 gallons per rupee. Because of the rebate the rate actually charged worked out to 19,662 gallons per rupee. The rebate has now been discontinued.

(4) Date pertaining to tube-wells energized after 31 March 1958, which had functioned only during a part of the year 1958–9, are excluded.

The marked Group-wise differences in utilization have to an important extent been due to regional differences in extensiveness of sugar-cane cultivation which in turn have been due to locations of the few sugar-mills. The most important of these mills is at Sardarnagar.

This dependence of irrigation development on the extent of sugar-cane cultivation is primarily due to the lower charges for irrigation from tube-wells in comparison with the working expenses involved in irrigation from traditional sources. In the case of the less water-needy *rabi* crops, traditional sources have managed to hold their ground to a large extent, thanks to the very high pressure of population on land which has resulted in tiny holdings, large surpluses of family labour and a pitiable level of wages. An additional factor in favour of traditional sources has been insufficiency of tube-well channels in general and brick-laid channels in particular. Because of volumetric charging, absorption losses have to be paid for, and the cultivators are so scared of such losses that they tend to take water only when available from brick-laid channels. Moreover, construction of water-courses which cultivators are expected to do themselves proves to be particularly problematic because of tiny holdings and rice cultivation which make cultivators extremely reluctant to provide passage for water-courses through their fields. However, in case of sugar-cane, and also other high-water consuming crops such as vegetables and green manure, the cost differential is so large that switch-over from traditional sources to tube-wells has been almost complete. Moreover, the cheaper tube-well irrigation has enabled considerable expansion of area under these high water-consuming crops and to some extent also under wheat.

Since this cheapening of irrigation mainly consists in avoidance of high labour charges involved in traditional irrigation, the question may be raised as to how far this cheapening may be considered advantageous in a labour-surplus economy. Such cheapening does prove advantageous because surplus labour, notwithstanding its zero opportunity cost from the point of view of the society as a whole, has to be paid wages when it is hired. Savings on account of these wages affect entreprenurial decisions as much as any other savings, leading to certain developments which would not otherwise come about. Expansion of area under sugar-cane in the Gorakhpur district is one such development. Moreover, cheaper irrigation does mean accrual of larger surpluses to cultivators. Their capacity to invest thus increases.

However, for this cheapening to be real, the cost actually involved in tube-well irrigation and not simply the charges that are levied on account of such irrigation must be taken into account. State tube-wells in eastern U.P. are run at a heavy loss. It is difficult to make a precise comparison between costs of traditional and tube-well irrigation. Costs of irrigation from traditional sources, as already mentioned, are highly variable, especially the monetary costs which even vary from family to family because of variation in the availability of family labour relative to area cultivated. Costs of tube-well irrigation depend to a large extent upon the degree of utilization. With the present average area irrigated per tube-well, irrigation charges will have to be very high indeed to cover costs. However, if tube-wells irrigated on average around 400 to 450 acres (gross) per annum, as the older tube-wells in western U.P. do, it would require little more than doubling of the present charges to make tube-wells remunerative in accordance with the official productivity criterion.[1] This seems to be roughly the condition for making new irrigation remunerative in U.P. generally and not merely the tube-well irrigation of eastern U.P. As in other regions, so also in the Gorakhpur district we seldom heard any complaint from cultivators regarding the charges being high. At least in case of crops, with large water requirements, such as sugar-cane, there appeared to be considerable scope for raising charges without altogether eliminating the cost differential that existed in favour of tube-well irrigation.

Whatever the position may be at present there is no doubt that from the long-term point of view tube-well irrigation is of major significance for the agricultural development of the region.[2] Traditional methods of irrigation are so inefficient that they cannot possibly cope with the requirements of a more developed agriculture, more so if there is a wider process of economic growth in the region tending

[1] The capital costs of tube-wells in the Gorakhpur district have been among the highest, ranging around Rs. 35,000 to 50,000 per tube-well. Assuming 400 acres of irrigated area per tube-well, the capital cost per acre would work out to about Rs. 87 to 125 per acre. To yield 4·5 per cent. return on this, an irrigated acre would be required to yield surplus of revenue over working expenses amounting to about Rs. 4 to 5·50. The working cost per annum of tube-wells inclusive of electricity charges average around Rs. 7,000 per tube-well. This would give an average of Rs. 17·50 per acre, so that average gross return would require to be Rs. 21·50 to Rs. 23. This may be compared with the average return of Rs. 11·35 per acre actually assessed in 1958–9.

[2] Eastern U.P. is among the most backward regions of the country and even if certain basic investments here may not be considered immediately justifiable in purely economic terms, it may still not be appropriate to postpone them, in view of social and political considerations, provided that they may be expected to generate in course of time the much-needed process of growth.

to push up the wage level from its present low position. Dr. B. N. Ganguli in his pioneer study, *Trends of Agriculture and Population in the Ganges Valley* (1938), has commented upon the capacity of north-eastern parts of India, including eastern U.P., to sustain dense populations on the basis of rain-fed paddy cultivation. Building up of prosperity, however, would be quite different from merely sustaining large populations. It is interesting to reflect that while regions like eastern U.P. with heavy rainfall and extensive facilities of traditional irrigation have sustained large populations, it is the naturally less favoured areas such as western U.P. and Punjab which have, thanks to state-organized intensive irrigation, built up comparatively prosperous conditions of agriculture. While the natural advantage was wholly encroached upon by population growth, it was the man-made advantage which initiated a certain process of economic growth. The experience is likely to be repeated in a more profound manner in the desert regions of southern Punjab and Rajasthan. With a highly favourable man–land ratio (which has been the result of adverse natural conditions in the past), introduction of irrigation in these regions will mean an immediate increase in family incomes, which before it is wholly encroached upon by population growth is likely to set up a cumulative process of development, especially if strengthened through other governmental measures. In regions like eastern U.P., which have long been subject to a heavy pressure of population, it will hardly be possible to build up prosperity mainly or primarily on the basis of agricultural development. However, like any other underdeveloped region, eastern U.P. is not only devoid of industry but also does not possess an advanced agriculture. It seems that as far as agricultural development is concerned, state irrigation has a basic role to play even in these regions.

V. *Factors and stages in irrigation development*

The preceding review of recent irrigation developments in Punjab and U.P., while bringing out the major regional differences, also brings out certain broad similarities. One finds, for instance, in almost all the regions, considerable and complex dependence of irrigation development on crop-pattern changes. In the beginning, extension of irrigation is limited because of the time taken by crop-pattern changes; but in the long run crop-pattern changes are more conditioned by irrigation. However, even in the long run crop-pattern changes depend upon a number of other factors. It was interesting to

find that in the regions studied, in spite of the wide differences in their physical circumstances, the broad direction of crop-pattern changes was similar. In particular, sugar-cane, wheat and paddy were being favoured as a result of expansion in irrigation facilities. Sugar-cane was quite limited in the desert and semi-desert tracts of southern Punjab, but it had already increased in areas where some irrigation had existed prior to the Bhakra canals. Wheat was the main beneficiary. Paddy, with its very high water requirements, was still not found on any considerable scale. However, rather surprisingly, paddy had become quite an important crop in the Karnal district which is only slightly less arid than southern Punjab. Wheat was the main beneficiary in southern U.P. also, with sugar-cane and paddy increasing slowly. Sugar-cane was the main beneficiary in central and eastern U.P. Paddy in eastern U.P. is normally rain-fed, but it has received great insurance as a result of tube-well irrigation. Expansion of irrigation facilities was also leading to increased intensity of cropping, but in this respect regional variations were more marked. In comparatively dry regions such as southern Punjab and southern U.P. growth of double cropping was a major result of increased irrigation. In eastern U.P., on the other hand, double cropping was already practised on an extensive scale so that tube-well irrigation meant little further increase in intensity of cropping, though the *zaid* or the third crop was improving to some extent with better irrigation facilities.

These crop-pattern developments were, of course, not taking place at a uniform pace. The response of cultivators varied. Organizational differences also proved to be important. For instance, wherever consolidation of holdings had already been completed agricultural developments were comparatively rapid. Then there were external factors, such as location of sugar-mills, which caused considerable variation in crop-pattern developments. Also land reclamation work was highly important for irrigation development in certain areas like the Karnal district in Punjab and the Jhansi district in U.P. Where large areas have become waste their reclamation is a prior condition for irrigation development. At the same time, however, reclamation becomes worth while precisely because irrigation facilities have become available.

Another broad similarity between regions was in regard to the limited nature of agricultural development that extension of irrigation was inducing, despite the wide possibilities. In Punjab and U.P. the effects of irrigation were largely confined to certain crop-pattern

changes and some improvements in the quality of produce. Improvements in techniques and increase in the use of manures and fertilizers have been restricted, not only in areas of new irrigation but also in areas of old irrigation. Moreover, such developments as were taking place in these spheres did not stem from extension of irrigation (though of course they became possible because irrigation had existed) but were largely autonomous, being directly the result of extension work and distribution of inputs under the community development programme. Indeed, the cultivators were scarcely appreciative of the fact that such vistas of agricultural development were opening up before them with the expansion of irrigation facilities. They were aware of the increased yields resulting directly from irrigation more or less unaided by additional fertilizers and manures and improved techniques, and they were aware of the possibilities of crop-pattern developments including possibilities of change-over from traditional to improved varieties of certain crops. But that was about all they saw in irrigation. Even crop-pattern changes were not very far-reaching though in this respect the awareness as to possibilities was much greater. In particular, the scope for vegetable growing and production of specialized fodders was well recognized, though developments in these respects were limited by other factors.

Finally, there is no doubt that serious bottlenecks in supply did exist as has already been mentioned. If there is one thing that can be done very simply and yet can do a great deal towards acceleration of irrigation development, it is to make the construction of all channels, including those going up to the fields, a responsibility of the irrigation department. (This, incidentally, will also take care of the widespread complaints of cultivators regarding inaccessibility of their fields to water supplied.) A field will then be either clearly within command or clearly out of it, without scope for any dispute.

The considerations emphasized in the above paragraphs clearly point to the need for distinguishing between a number of stages in irrigation development. The first stage may be defined as the one in which changes in cropping pattern and in agricultural practices generally are quite limited, so that the major benefit of irrigation consists in providing security to the existing state of cultivation. This is also the period in which supply bottlenecks, in particular the dearth of field channels, loom large. The second stage may be taken to be the one in which supply bottlenecks have been generally removed, extensive crop-pattern changes have come about and cultivators have

become fairly well acquainted with methods and possibilities of wet cultivation. One would expect in this stage more or less full utilization of irrigation potential. However, an intensive use of complementary inputs and the more profound improvements in agricultural techniques, for which the basis has been laid down through irrigation, have yet to come about. It is such developments that may be considered symptomatic of the most advanced stage of irrigation development. But the relationship between provision of irrigation facilities and the more profound advancements in agriculture is quite tenuous. The former does not necessarily lead to the latter.

Evidently there is much scope for compressing these stages through suitably planned measures. The principle is quite simple. A given quantum of investment deployed in suitable proportions over a sufficiently wide range of related spheres would yield better returns on investment in each of these spheres than the same investment in any one sphere alone. This simple principle does not seem to be recognized even within the restricted sphere of construction of irrigation works. While more and more headworks and main canals are constructed, the completion of branches and field channels is allowed to lag, with the result that the large investments already made are allowed to yield small returns for want of some additional investment. What is actually necessary is not merely that all construction jobs connected with an irrigation scheme are, as far as possible, completed simultaneously, but that the scheme itself forms a balanced component of a more comprehensive programme of agricultural development in any region where irrigation is introduced. All the various programmes of agricultural development are undoubtedly provided for under the Plans. But in the course of our investigations in different regions it appeared that these aspects tended to move severally rather than in a dovetailed manner. And other measures tended to lag behind the provision of irrigation.

Viewing irrigation development as comprising a number of phases, one also appreciates better the problems involved in recoupment of costs. Financial returns from irrigation evidently depend upon (*a*) the degree of utilization of capacity, and (*b*) the rate of return per irrigated acre, which in turn depends on (i) the level of charges and (ii) the proportion in which area irrigated is divided between the comparatively high-charged and the comparatively low-charged crops.

The regions of older irrigation in Punjab and U.P. may be considered as broadly approximating to the conditions typified in our

stage II rather than to stage III. In 1955–6 the value of fertilizers and manures (mainly home-produced farmyard manure evaluated at prevailing village prices) averaged no more than Rs. 7·5 per acre on sampled farms (of which 71·6 per cent. of area was irrigated) in the two selected districts of U.P., the total value of inputs on these farms (including imputed values of family labour and other returns to family resources) being Rs. 184·7 per acre.[1] On the sampled farms in the two selected districts of Punjab, 75·3 per cent. of area was irrigated. Value of fertilizers and manures on these farms averaged only Rs. 3·3 per acre, the total value of inputs averaging Rs. 156·0 per acre. For Punjab the break-up of data is available according to irrigated and unirrigated areas also. It was found that no fertilizers and manures were used on the unirrigated area. On the irrigated area their value averaged Rs. 4·4 per acre out of the total per acre value of inputs of Rs. 181·5.[2] In both Punjab and U.P., the most important input items were human and bullock labour, together accounting for 48·5 per cent. and 68·8 per cent. of the total values of inputs in the two states respectively. Another important input item in Punjab was the rental value of land, which indeed was even more important than either human or bullock labour, accounting for 35·8 per cent. of the total value of inputs. In U.P. rents were not so important, though they were still quite important (accounting for 9·3 per cent. of the total value of inputs). Seed and upkeep of implements were comparatively important items in U.P. but hardly so in Punjab. Significantly, human and bullock labour and the rental value of land were also the items accounting for the bulk of the increase in the value of inputs from unirrigated to irrigated areas in Punjab. Fertilizers and manures were used only on irrigated areas, but they did not account for much in any case.

In these circumstances, there would not be much difference in productivity of crops on irrigated lands in areas of old and new irrigation. Nor, accordingly, would there be need to fix lower rates in the latter areas than in the former areas, as is sometimes suggested. Our impression was that over a considerable range around the existing level of rates demand for irrigation was likely to be quite inelastic. Clearly, other measures were required for remedying the problems of under-utilization.

[1] *Studies in Economics of Farm Management in U.P.*, Report for the year 1955–6 issued by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India, pp. 8 and 36.

[2] *Studies in Economics of Farm Management in Punjab*, Report for the year 1955–6, pp. 12, 83–84 and 91–96.

However, while it may be possible to raise rates considerably over their present levels, it may not exactly be possible to make new irrigation pay for itself simply on the basis of existing productivities. We find from the Punjab farm-management report that the farm business income[1] on irrigated areas averages Rs. 88·0 per acre while on unirrigated areas it averages Rs. 24·4 per acre, yielding a difference of Rs. 63·6 per acre. To this must be added irrigation charges, which averaged Rs. 6·0 per acre, in order to get the margin of net benefit from irrigation. This would, of course, not be the same thing as the paying capacity of irrigation, for it would by no means be possible to siphon off this entire benefit by way of irrigation charges. If this were done there would be no inducement to cultivators to put in all the additional effort that is required in irrigated cultivation. The paying capacity of irrigation would thus be some fraction of this benefit.

It is not an entirely simple matter to work out the average cost of irrigation per acre so as to be able to compare it with the per acre net benefit from irrigation. In the first place, there is some difficulty about the degree of utilization of potential that can be assumed for the purpose. With considerable under-utilization, cost per irrigated acre would be very high, and would be clearly unsustainable on the basis of existing productivities. However, it seemed to us in the course of our investigations that the problem of under-utilization in Punjab and U.P. was essentially a transitional problem. The potential demand for irrigation in the context of agricultural development appeared to be high in all regions, so that it would not be inappropriate to assume more or less full utilization in the long run.

A more intractable problem in estimating the cost of irrigation is regarding the charge that can appropriately be made on investment. We have already indicated (in section I) some of the more serious complications involved in estimating this charge on rational economic considerations. The rate of return that is officially required on capital invested in irrigation is 4·5 per cent. On this basis, and assuming full utilization, the average yield of revenue per acre would need to range around Rs. 20 to 25 on different irrigation works in order to cover costs. This would require about doubling the level of U.P. rates and about quadrupling the level of Punjab rates. Such an increase in the level of rates may not be entirely unsustainable on the basis of existing productivities. Visualizing more intense agricultural

[1] Farm business income is gross income minus all expenses actually incurred in the process.

developments in future, of which the scope is undoubtedly large at the present stage and for which a basis is laid down through provision of suitable irrigation facilities, it should be possible to make irrigation a paying proposition in the long run not only on the basis of the present required rate of return but even on the basis of a higher rate of return that may be considered more appropriate. But the question is whether it will be politically feasible or socially desirable, especially if it tends to affect adversely the inducement on the part of cultivators to develop agriculture.

Hence one needs to look at the question in a somewhat different way. In the case of a basic industry such as irrigation, of which the essential function consists in making other developments possible, it is very necessary to keep the dynamics of the situation fully in view. Even supposing that some method has been devised (howsoever rough and ready) to compare different outputs emerging at different points of time so that investment–output ratios in different industries could be worked out, it would still not be appropriate (probably not even possible) to go simply by such ratios in deciding upon the pattern of inter-industry investment, except possibly on the assumption of an open economy with the same balance of payments elasticities of transformation of all goods and, furthermore, on the assumption—which would be even more unrealistic—that all goods and services could be imported. Some investments may not have high immediate yields but may be crucial to productive processes (and unsubstitutable through imports). They should be suitably credited for this attribute. One may either postpone them until their lack becomes a sufficiently serious bottleneck in economic development to raise their rate of return sufficiently, or one may plan ahead to avert the possibility of their becoming a serious bottleneck by accepting comparatively low initial rates of return. Irrigation in India clearly falls into this category.[1]

[1] When Mr. Colin Clark mentions low marginal returns from irrigation in India and therefore doubts if the large dams now under construction would be economical (see his *The Economics of Irrigation in Dry Climates*), he is evidently taking a purely static view of the situation. Significantly enough, he finds high marginal returns from irrigation where agricultural yields are high already. This clearly indicates the complementary nature of irrigation and other developments in agriculture. Surely a similar situation should be planned for in India. The benefits from irrigation would better be judged in the long-term perspective when other conditions are also changing rather than from the short-term point of view when other things remain more or less constant.