Neglected Opportunities in Irrigation

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This article considers two different programmes which attempt to improve water use and management in eastern India. One concerns the Hirukud project, which irrigates 282,000 acres in the Sambalpur district of Orissa; the other is in the Raipur district, just west of Sambalpur in Madhya Pradesh. Both projects attempt to improve water use and management of existing irrigation, by installing field channels to give farmers better control over the water in each field.

The two projects represent the two ends of the cost spectrum. The Raipur project is capital intensive and costly relative to the Sambalpur project which consists of a simple system of village field channels installed at minimum cost. This article reports on the internal rates of return from these projects and highlights the importance of technically trained people and alternative project designs in making projects viable.

OVER the centuries, sizeable investments have been made in India to develop the irrigation potential; and these investments have continued during more than the quarter century of independence. By 1968-69, the net irrigated area was 71 million acres or about 21 per cent of the net area sown. The 1968-69 level of irrigation is 17 per cent above the 1960-61 level and 38 per cent greater than in 1950-51. However, there is wide variation in the type and quality of irrigation. Over a third of the irrigation comes from government canals, 17 per cent is from small reservoirs (tanks), 8 per cent from tube-wells, and the remainder from other wells and private canals.

With the advent of high-yielding varieties (HYVs) of wheat and with the increased use of fertiliser, the returns to irrigation increased sharply, leading in turn to rapid expansion of private tube-well irrigation, particularly in north-western India. The more recent spread of HYVs of rice and the continued population pressure, have pushed up the returns to irrigation in many of the high rainfall areas of eastern India. Here, the irrigation is used to supplement rainfall during the wet season (kharif) and to allow production of one or two dry season (rabi) crops.[1]

In eastern India, canal irrigation is dominant, with water flooding from field to field where farmers have little control over the flow of water. Once the water is in the main channel, the outlets are usually never closed; consequently, the water flows continuously through the fields and the water distribution is quite uneven. In fact, water may not always reach those at the end of the service area or at the end of the canal.

Although the future opportunities for building additional reservoirs and for extending canals are limited, one important mode of extending irrigation remains largely untapped. This is the improvement of existing irrigation projects. In 1972, the Irrigation Commission of India reported a large potential for utilising current irrigation potential more fully through installation of field channels [1, p 399]. Don Williams has reported similar findings in his work in India[2].

In this present article two different programmes are considered which attempt to improve water use and management in eastern India. One concerns the Hirakud project, which irrigates 282,000 acres in the Sambalpur district of Orissa; the other is in Raipur district just west of Sambalpur in Madhya Pradesh. Both projects attempt to improve water use and management of existing irrigation, by installing field channels to give farmers better control over the water in each field.

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Project Design

In the case of Sambalpur, the Intensive Agricultural District Programme (IADP) staff introduced a programme for installing field channels and demonstrating their use in two villages. The basic idea was to provide a small unlined channel from the canal outlet along the field levees to each farmer's plot, thus giving each farmer control over the flow of water onto his fields. Placing the channels along the levees minimises the quantity of land taken out of production. Initially, a major extension effort was needed to get the approval of the entire village, because just a few farmers nearer the canal outlets could prevent the installation of the field channels by refusing to allow their passage along or through their fields. When several villages were thus improved, other villages became interested; now village approval is not difficult to obtain.

Once a village agrees to the programme, IADP provides the technical assistance needed to design the complete village system; it also provides the materials (rock, concrete and pipe) needed to instal the field channels. Drop structures are required to prevent erosion in places where there are significant changes in elevation, while pipes are needed under road crossings. The IADP staff also demonstrates the use of HYVs, fertilisers, and pesticides; further, it assists in maintaining the newly constructed village irrigation systems. The villagers contribute the labour for digging and maintaining the channels. At the time of this study in 1971, four village systems had been completed, nine more were in progress, and a number of others were waiting for assistance.

The Raipur project, a co-operative project between the Ford Foundation, IADP, and the State Agricultural College, is much smaller than the average Sambalpur project and involves only 26.6 acres in a small reservoir (tank) irrigated village. It included lining a 2000-foot main channel with bricks and cement as well as 10 feet of each of 10 lateral channels. Unlined field channels were constructed from the 10

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laterals to each of the farmers' fields within the 26.6-acre project area. Two surface drains, each 2,500-foot long, were constructed to drain the excess water to the main drain, which runs along the eastern boundary.

The Raipur project is far more expensive than the ones in Sambalpur; but it is a more complete system which includes drainage. The Sambalpur projects do not include the lining of any channels, while this one of the major costs of the Raipur project. The Sambalpur projects represent the lower bounds for the cost of improving a village irrigation system while the Raipur project approaches the effective upper bounds of cost; indeed, had the field channels been lined or land levelling been required, the costs would have been even higher.

Natural Resources

The Raipur and Sambalpur projects are in the rainfall zone, which generally permits the production of a wet-season rice crop. The irrigation water supplements the rainfall and assures the production of a wet-season rice crop, while during the dry season crops cannot be grown without irrigation. When the rainfall is short, adequate water may not be available for the dry season, particularly in Raipur.

For over 10 years, the Sambalpur farms have irrigated two crops of rice each year. Currently, the dry season crop is the more productive: insect damage has cut down on the use of HYVs and has reduced production in the wet season. In contrast, Raipur village is assured of only one rice crop, with a second crop being possible in a limited area every two or three years. A small reservoir provides water for the Raipur project village, along with several others; depending on the quantity of water in storage after the first crop, water may also be available for a second crop. However, the criteria used by the Irrigation Department, to determine which villages get the remaining water, are not clear.

The climate is not significantly different in the two areas. Both experience hot, dry, weather from April to June, followed by the monsoon, which brings heavy rains during June to September and sometimes in October. At least 90 per cent of the rainfalls during the monsoon, and it is critical for the wet season crop as well as for filling the reservoirs.

Sambalpur has four types of soils which are determined by the land slope. The upland soil is generally difficult to irrigate and is restricted to crops requiring less water than rice. The two middle-level soils are suited to growing most crops and produce a good rice crop when irrigated. The bottom land has the best rice-growing soil, but with the seepage caused by irrigation it is now restricted almost exclusively to rice production. Within the Raipur project there is only one type of soil and it is suited to growing rice or other crops, such as pulses, millets, or vegetables. In all cases, water is the limiting resource — not soils.

During the survey in the crop year 1970-71, the rainfall was adequate for a good crop of rice in both areas. In addition, enough water was available to irrigate a dry-season rice crop. However, in Raipur, a second crop was not grown in order that the water management project could be started. Only one of the six villages surveyed in Sambalpur experienced a water shortage during the dry season and all villages produced a second rice crop.

Impact of Field Channels

To measure the economic impact of the improved irrigation systems in Sambalpur and Raipur, three surveys were conducted. In Raipur, a complete village survey covered all landowners (with the exception of six absentee landowners) and accounted for 95 per cent of the irrigated land in the village. This survey provides a base against which comparisons can be made once the new irrigation system is in operation in the village. In Sambalpur, three types of villages were surveyed twice (once after each crop season) in order to examine the current impact of the irrigation project and to provide a basis for future study. The three types surveyed were: (1) two villages with field channels and a demonstration (*improved* villages), (2) two villages with the channels being installed (*improving* villages), and (3) two villages which needed to instal channels (*control* villages). The *improved* villages can be compared with the *control* and *improving* villages, to measure the differences in income and input-use resulting from the field channels. Then, in several years, the *improving* villages can be resurveyed to measure their improvement over time due to the field channels.

In the Sambalpur study, a random sample of 195 farms was taken from the six villages so that approximately 20 per cent of the owner cultivators were included from each set of two villages. Each farmer included was interviewed twice, so that the information concerning each crop was still fresh in his mind. The sample was also drawn so that it was representative of small, medium, and large farms.[8] The Raipur study involved the survey of owner-cultivators — 70 in all. Since, in both cases, owner-cultivators accounted for almost all the land cultivated, the results are representative of the villages. However, the sample in Sambalpur was drawn in such a way as to be representative of each set of two villages.

Cost of Improvement

In India, where most of the farm land is privately owned, the improvement from irrigation must be financially attractive to the farmers if it is to be widely adopted. If the cost is too high relative to the returns, the project will not spread. The expansion of tube-well irrigation in northern India is an example of what can happen if profits are high from private irrigation investment [6]. Of course, there are additional problems, associated with improving flood irrigation, which do not plague tube-well irrigation. Foremost among these is the need to organise farmers and provide them with technical assistance. In the case of tube-wells, one individual can make the decision to instal the irrigation facility; but improving a flood irrigation system requires a group decision within one village or among several villages, as well as the support of the Irrigation Department and the agricultural officials. In Sambalpur, both the Irrigation Department and the IADP were involved in providing field channels. The Raipur project had the support of IADP but was not fully supported by the Irrigation Department. In all cases, the villages fully supported the projects.

The cost difference between the two projects is striking, with the Raipur project costing 26 times as much per acre as the projects in Sambalpur. The total cost of the Raipur project was Rs 24,000 — only Rs 1,000 less than an average Sambalpur project which covered about 750 acres. The pilot nature of the Raipur project, and the fact that it is a complete irrigation system with drainage, explain some of the differences. For the Sambalpur projects, costs were held to a minimum in the hope that drainage and the lining of some channels could be done at a later date, once the benefits from the field channels had been experienced by the farmers.[9]

The Sambalpur IADP divides improvement of irrigation into three stages: (1) approach and survey of interested villages, (2) installing field channels and (3) repair and maintenance of the field channels. Once the village has been selected, the IADP water management staff starts to plan the field channel system from each canal outlet. The size of the village determines the number of outlets to be installed, as each outlet is capable of supplying water to irrigate 25 acres or more. The IADP staff works with the farmers in deciding the location of the field channels and helps install the necessary structures. The cultivators are required to dig the channels, which are generally one foot deep, one and one-third feet wide at the base, and two feet wide at the top. Every year, the field channels need repair while the land is being prepared for planting — at an estimated average cost of about Rs 6 per acre. On many of the smaller farms, the labour for channel repair and maintenance appears to have a low opportunity cost. Thus the above estimate based on average wage rates may be high.

The original cost estimate for installing the improved irrigation in Raipur was Rs 27,000, while the actual expenditure for constructing the main channel, the 10 lateral channels, and the two surface drains was Rs 22,000 [3]. Although this was partly a training project, Rs 2,000 should be added for technical assistance and for installing the field channels. The maintenance cost should be about Rs 5 per acre, which is slightly lower than the cost in Sambalpur because the lateral channels are partly lined in Raipur and should require less maintenance.

Another striking difference between the two projects, besides the cost per acre, is the capital labour ratios (see Table 1). The Sambalpur approach is less demanding of non-labour inputs, particularly capital. Slightly less than 30 per cent of the Sambalpur project costs are construction materials as compared to over 62 per cent for construction materials in Raipur.

TABLE 1: COST OF IMPROVING IRRIGATION

	Sambalpur	Raipur
	Rupees/acre	
Construction materials	10	564
Labour	6	225
Technical assistance	18	75
Other	—	38
Total	34	902

BENEFITS FROM IMPROVEMENT

Currently, the only measure of benefits from field channels is a comparison between the Sambalpur villages, since the construction of the Raipur project was just started at the time of the survey. Both the *control* villages and the *improving* villages provide a base against which the *improved* villages can be compared. Yields, input use, proportion of high-yielding varieties, cropping intensity, area irrigated, and net returns, all give an indication of the impact of the field channels on the village crop economy.

Installation of field channels could increase the area irrigated and the cropping intensity within the village by improving the efficiency of water use through reduced over-irrigation and reduced wastage of water near the outlet. Better control over the quantity of water applied would allow changes in the cropping patterns and improve the timeliness of irrigation as well as other farming operations. Better control could, moreover, increase the use of nitrogen fertiliser by reducing the amount lost in the flooding. Under the field-to-field irrigation system, all but the uplands must be planted under rice or face the problem of flooding. The more efficient application of water, by improving production possibilities, could increase the returns from using HYVs fertiliser, and other inputs. Both the adoption of relatively more labour-intensive crops and higher cropping intensity would increase the opportunities for employment in agricultural occupations. In addition, the construction and maintenance of the field channels would increase labour requirements.

A note of caution should be observed in this comparative analysis. There are always subtle differences among villages, which cannot be controlled. These differences, such as better leadership, can equip one village far better for economic improvement than the other. Thus, some of the changes observed in the *improved* villages may be due to uncontrolled variables which are not duplicated in other villages and cannot be attributed to the field channels. However, adoption rates before and after the installation of field channels indicate that the villages had very similar potentials.

Based on the limited amount of historical data collected for the *improved* villages, the cropping intensity and irrigated area did increase after the field channels were installed. The proportion of the village cropland irrigated increased from 84 per cent to 97 per cent, while cropping intensity rose from 187 per cent to 196 per cent. The irrigated area in the *control* and *improving* villages was only 84 per cent and 75 per cent, respectively, while cropping intensities were 185 and 157 per cent.

The proportion of rice grown is not significantly different among the villages, except for the *improving* villages during the dry season (see Table 2). But the acreage of high-yielding varieties is significantly greater in the *improved* villages during the dry season, 72 per cent as compared to 54 and 41 per cent. This is very important, because the average yields of HYVs are 5.2 and 5.5 quintals per acre more than the local varieties[4] (see Table 3).

Even within seasons, and by varieties, the *improved* villages have higher rice yields. During the wet season the yield difference ranges between 3 and 5 quintals an acre, while in the dry season the difference is between 2.9 and 3.5 quintals per acre for local varieties, and 2.6 and 3.2 quintals per acre for high-yielding varieties.[5]

As would be expected, the use of purchased inputs is also higher for the *improved* villages. The difference in fertiliser applied per acre is between 5 and 11 kg per acre during the wet season, and this increases to between 12 and 17 kg per acre in the dry season for local varieties and to 14 to 18 kg per acre for the higher-yielding varieties (see Table 4). In terms of percentage increases in fertiliser use on local varieties, the largest increase — of 33 to 55 per cent — came during the dry season, followed by the wet season — 17 to 46 per cent. Although the absolute increase is the greatest on the high-yielding varieties, the percentage increase is only 21 to 28 per cent.

The other major annually purchased input — *viz*, plant protection materials — exhibited similar differences in use. The big difference occurs on the high-yielding varieties during the dry season, where the *improved* villages used slightly over twice as much (see Table 5). There is no difference for local varieties in the dry season; but during the wet season the *improved* villages again use about twice as much.

In addition, the *improved* villages employed 80 per cent more credit than the other villages, with 70 per cent of this difference being accounted for by two large farmers who borrowed a total of Rs 41,000 to purchase tractors. Much of the remaining credit

TABLE 2: DISTRIBUTION OF CROPS BY SEASON, 1970-71*

	Local Rice Varieties	High-Yielding Rice Varieties	Other Crops**
	(Percentages)		
Wet Season			
Improved villages	92	5	3
Control villages	94	1	4
Improving villages	90	6	4
Dry Season			
Improved villages	27	72	1
Control villages	44	54	2
Improving villages	48	41	10

Notes : * Percentages may not add to 100 per cent due to rounding.
** Other crops included wheat, pulses, oilseeds and vegetable crops.

TABLE 3: RICE YIELDS BY SEASON AND RICE VARIETY, 1970-71

	Improved Villages	Control Villages	Improving Villages
	(quintals per acre)		
Wet season local varieties	10.0	7.1	5.1
Dry season local varieties	13.7	10.2	10.8
Dry season HYVs	18.9	15.7	16.3

went for fertiliser and labour with smaller amounts going for plant protection materials and seed. Almost two-thirds of all the credit went for fertiliser while non-agricultural uses accounted for only 3 per cent of the total.[6]

INTERNAL RATE OF RETURNS

If these differences in high-yielding varieties, yields, and input use, are translated into costs and returns, the improved villages have significantly greater net returns for both seasons. The net returns for the year were Rs 300-350 higher in the *improved* villages than in the *improving* and *control* villages.[7] With the costs as low as they are in the Sambalpur project, it is not critical whether the net returns per acre are Rs 100 or Rs 300. In either case, the internal rates of return are very high and exceed the rates on most other agricultural investments. Only 10 to 15 per cent of the difference in net returns during one year is needed to cover project costs.

In contrast, even if the same types of benefits occur in Raipur, the amount of the net returns stream is very critical. Assuming a 10-year project life, the net benefits per acre must exceed Rs 150 per year for the internal rate of return to reach 10 per cent, while the internal rate of return will be 17 per cent if the annual net benefits are Rs 200 per acre. Although the Sambalpur experience might be transferred to Raipur for the wet season, the same is not true for the dry season. Even with the improved irrigation system, water would be available for dry season irrigation only every second or third year. Thus, annual net returns of Rs 200-250 per acre are probably the upper limits for the Raipur project. For acres with only a wet-season crop, the annual returns, based on the Sambalpur analysis, would be in the range of Rs 140-150 per acre.

This suggests the need for a less capital-intensive project than the Raipur project. If costs were cut by half, by increasing the area served by the main channel, and if benefits were Rs 150 per acre, the internal rate of return would be almost 30 per cent.

PROSPECTS FOR IMPROVEMENTS

The two studies in eastern India point out very forcefully the possibilities for high returns from improving many of the existing flood irrigation systems in India. Several problems are also apparent. One is the technical assistance restraint, which limits the Sambalpur programme to only nine villages a year. At this rate, it will be at least 40 years before all the irrigated villages in Sambalpur District can be reached by the programme. Farmers themselves cannot do the necessary engineering and surveying work to design even the simple Sambalpur irrigation system. Currently, in India, there are unemployed engineers, but most of them neither have the desire nor are trained to do this type of irrigation work. In addition, except in a few cases such as the ones mentioned above, programmes are not available on the shelf to employ engineers to design improved irrigation systems. Thus, India could benefit greatly from: first, increasing the number of technicians who can design and maintain village irrigation systems; and second, creating the positions and employing the technicians in irrigating rural areas.

A further problem is the need for some new institutional arrangements, within villages, for maintenance of the new irrigation systems. This will be particularly critical in India, where low levels of farm income do not leave much for maintenance of irrigation systems. An improved means of allocating water among the villages is also needed. Many of the villages in Sambalpur, near the head of the main canal, waste water even as those near the end are able to irrigate only half their land during the dry season. Water charges are based on a farmer's acreage, so excess water does not cost the farmer any extra. Pricing of water on the volume used, and a better policing of actual water-use, would greatly improve the efficiency of on-farm water-use. In fact, it might encourage villages to devise better ways of distributing water both within and among the villages.

Due to the cost and difficulty of measuring the volume of water delivered to each farmer, the village could be used as the point of measurement. The government would set the charge per volume of water used, but the individual farmer would still pay a rate based on the acres irrigated. The rate would vary, however, depending on the amount of irrigated acres in the village and the volume delivered to the village. Thus the more efficiently the village farmers use water, the smaller would be the charge per acre. This, or some variant, should at least be tried to see if economic incentives working through the village could improve water use.

Although nothing conclusive can be said about the optimum type of village irrigation, several important conclusions may be drawn from the projects reviewed.

First, the Sambalpur programme should now include drainage as a key element in the irrigation system. The farmers clearly understand the benefits from the field channel, and it is time to provide a more complete irrigation system.

Second, the farmers should pay the full cost of installing the field channels, since their increased returns cover costs in the first year.

Finally, the Raipur project points out

Table 4: Fertiliser Use by Season and Rice Variety, 1970-71

	Improved Villages	Control Villages	Improving Villages
	(kg per acre)		
Wet season local varieties	35	30	24
Dry season local varieties	38	36	31
Dry season HYVs	82	64	68

Table 5: Plant Protection Expenditures by Season and Rice Variety, 1970-71

	Improved Villages	Control Villages	Improving Villages
	(rupees per acre)		
Wet season local varieties	6	4	2
Dry season local varieties	2	2	2
Dry season HYVs	15	7	7

the danger of building a project which is too capital-intensive and too costly. One must always keep in mind that, for these projects to spread, the costs must be low enough to afford high net returns to the farmers, and if the construction and maintenance are labour intensive, the farmers' actual rupee expenditures will be low. The expansion and interest in the Sambalpur programme is a clear indication of what is possible.

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Notes

1 The wet season is the monsoon or kharif season which starts in June and ends in December. The dry season is the winter or rabi season which runs from January to May.

2 The farm size was based on land holdings which included land rented in but excluded land rented out. The different size categories are as follows:
Small farms
3.5 acres and under
Medium farms
3.6 acres to 7.5 acres
Large farms
above 7 5 acres

3 The field channels have also improved the surface drainage during the wet season. However, a complete drainage system including some main drainage outlets could add between rupees 10 and 100 per acre to the project costs.

4 One quintal equals 100 kilograms or 4.9 bushels of rough rice.

5 Not enough high-yielding varieties were grown during the wet season to provide a valid comparison.

6 This is quite different from the Raipur village, where 20 per cent of the total credit went for non-agricultural uses and 27 per cent for fertiliser.

7 The net returns do not include anything for the additional acreage irrigated in the *improved* villages. Therefore, the net return may understate the total village returns.