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A FARMER SURVEY AND VILLAGE COMPARISON TO EVALUATE IRRIGATION IMPROVEMENT IN SAMBALPUR, INDIA

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The paper is organized around four major headings. First, a statement of the problem and a description of the setting in which the study was conducted. Second, a description of the research design and data collection procedures along with a discussion of why these were used. Third, a discussion of the strengths and weaknesses of the data collected. Finally, a discussion of how the project considered technology variables and the policy implications that were derived from the research. The study deals only with farm level irrigation in eastern India and does not consider other possible problems in the irrigation system. The purpose was simply to determine if a district program, to improve irrigation at the farm level, was economically successful. We used farmer survey data to compare villages with and without improved irrigation and did the first part of the work needed to compare villages over time.

A. Problem and study setting.

In the irrigated rice growing areas of eastern India, canal irrigation

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is dominant, with water flowing by gravity from field to field. Such a system is like the one shown in figure 1 but without the field channels. As many as 20 farmers are served by the same outlet which is usually never closed, leaving water to flow continuously throughout the crop season. This unregulated water flowing through ungraded terraces with different sized plots owned by different farmers causes heavy loss of water. Water may not even reach those at the end of the service area or at the end of the canal. The uncertainty of the water supply can be substantial for farmers most distant from the outlets. For the farmers near the outlet there are flooding problems and a fear that fertilizer is being lost as the water flows through their fields. Even though very little fertilizer may be lost in the water, farmers believe the loss is significant.

These gravity flow systems with limited farm level structures can deliver water at relatively low cost. However to be effective they require land ownership patterns that are either highly concentrated or that meet special distribution requirements. In other words only one or two farmers can own the land irrigated from one outlet. This means either large land holdings such as one finds in the Western U.S. or long, narrow farms extending from the main channel to the end of the service area as Wickham found in the Philippines [Easter and Martin].

An alternative to these specialized ownership patterns is to install laterals or field channels to each farmer's field. However, the laterals or channels beyond the outlets are the responsibility of the farmers in contrast to the main canals which are provided and maintained by the Government of India. If field channels are to be constructed, the farmers must build them. But without technical assistance to design and help construct field channels the individual

farmers do not build the channels [National Commission on Agriculture; Williams].

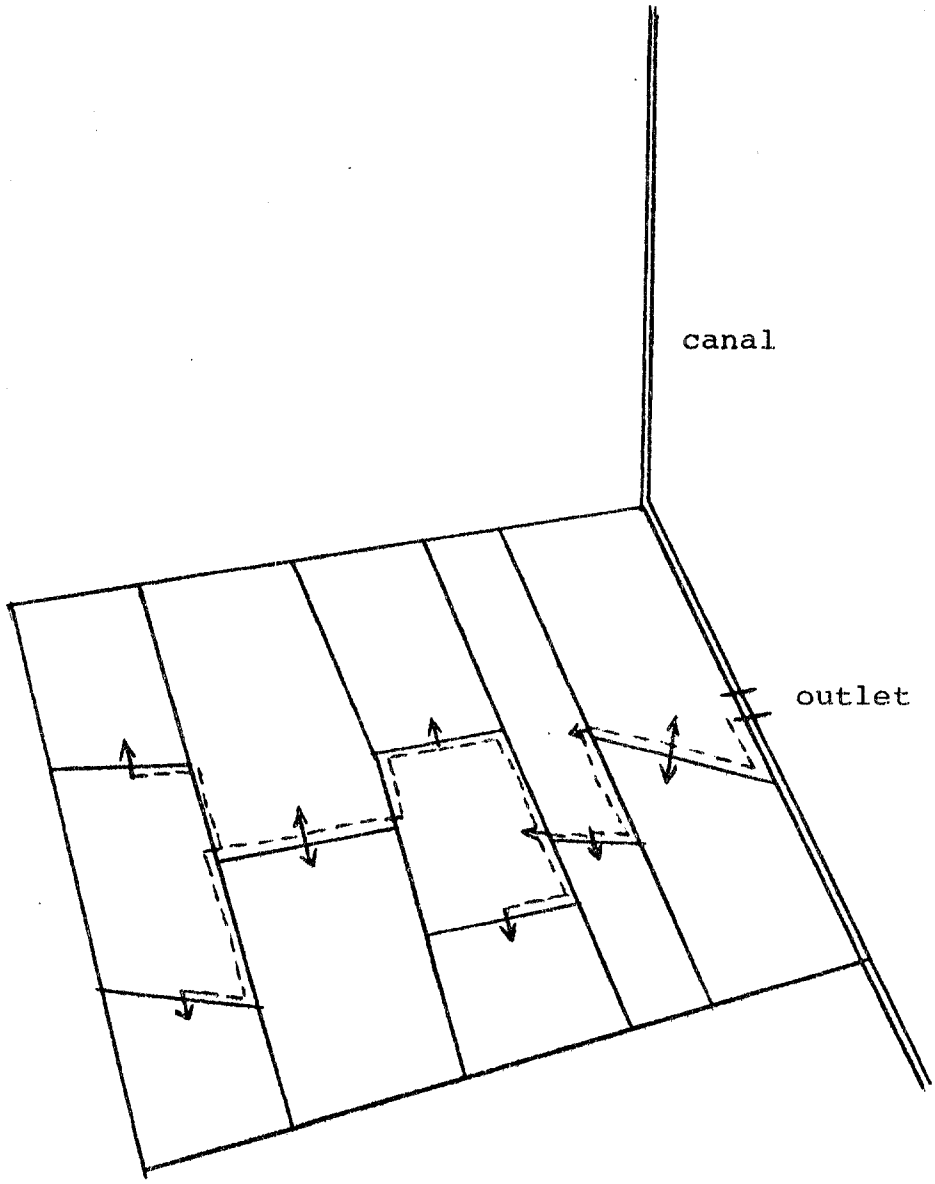
In 1966 a program was established in Sambalpur district of Orissa State to improve irrigation at the village level in the large Hirakud irrigation project. The Hirakud project irrigates approximately three hundred thousand acres and 450 villages. Water delivery started in 1956 but farmers made only limited use of the irrigation in the early years [Nair]. Most of the farmers had little or no experience with irrigation. In addition, Orissa is an old princely state and very backward. To encourage farmers to use the water, annual irrigation charges were lowered to about a dollar per acre in 1961. These same low rates were in effect during the study period, 1970-71.

The irrigation improvement involves installing field channels or laterals and demonstrating their use in a village. A small unlined channel is dug from the canal outlet along the field levees to each farmer's field (see figure 1). The farmers are then able to control the water on their fields by opening or closing an outlet in the field channel. Placing the channels along the levees minimizes the quantity of land taken out of production. Initially a major extension effort was used to obtain the approval of the entire village, since a few farmers owning land near the canal outlets could prevent the installation of field canals. After several villages had installed the field channels, other villages became interested and the problem now is to decide which villages to help.

The district staff provides technical assistance as well as the materials (rock, concrete and pipe) needed to construct drop structures for erosion control and to route water under roads. The staff also demonstrates the use of HYV's, fertilizers and pesticides and checks on the maintenance of the new systems. The farmers are required to dig and maintain the field channels.

FIGURE 1

The Village Irrigation System



---- field channels

═══ canal

——— borders on levees in the fields

The district staff work directly with the farmers when deciding which alternative route to use for the field channels. By 1970 four village systems had been completed and nine more were to be improved in 1971, while a number of other villages had asked for assistance.

Our study was designed to evaluate the irrigation improvement program both under existing conditions and over time. The question was, should the Government of India invest more funds in irrigation improvement in Sambalpur? Since about 400 villages could use assistance it would take over 40 years to complete the work at their 1971 capacity of nine villages per year. If the program was very profitable, maybe it should expand to 40 or 50 villages a year.

B. Research design and data collection.

To evaluate the economic impact of the irrigation improvement, farmers from six irrigated villages were surveyed twice; once after the wet season and once after the dry season. The survey included two out of the four villages with improved irrigation (improved villages), two out of the nine villages which were going to be improved in 1971 (improving villages) and two villages which needed improved irrigation (control villages) but were not likely to obtain it in the next two or three years. The villages were selected so that they had approximately the same availability of water. One control village had to be replaced because its leader was uncooperative.

A random sample totaling 195 farmers was taken from the six villages which was slightly over 20 percent of the owner cultivators from each set of villages. The sample was also selected so that it was representative of three farm sizes; small farms 0.5 to 3.5 acres, medium farms 3.6 to 7.5 acres, and large farms

over 7.5 acres. None of the large farms exceeded 30 acres of cropland. A larger percentage sample was taken from the medium and large farms since we expected a greater variation among these farms. Farmers were interviewed right after each harvest period so that input and production information was still fresh in their minds. However, several small farmers could not be located during the second survey so the dry season sample was reduced to 190 farmers. Since owner cultivators account for almost all the land cultivated, the sample accounted for over 20 percent of the villages' cropland and was considered to be representative of the economic impact of the irrigation project on the villages.

The improved villages are compared with the control villages while the improving villages were to be resurveyed after the irrigation improvement was finished and the economic changes compared over time. The irrigation improvement is evaluated in terms of its effects on yields, input use, adoption of HYV's, cropping patterns, cropping intensity, area irrigated and net returns.

Sambalpur is an Intensive Agricultural Development District in which the Ford Foundation had worked for almost a decade. Good working relationships had been established well before the survey. In fact, the study was conducted only after a number of visits had established that the district staff was sincerely interested and would provide full support. The district office provided transportation, housing and other support for the survey team. They also helped obtain village participation in the survey. Without their assistance the survey would have been impossible.

The data were collected by two Ford Foundation staff people from India with experience in survey work and two agricultural economics graduate students from the Indian Agricultural Research Institute. One of the Ford Foundation

staff persons with extensive survey experience in India supervised the survey. One of the graduate students used part of the data for his Ph.D. thesis and was a key person in the interviews.

Several things dictated the procedure used to evaluate the irrigation improvement. Since we wanted to evaluate the project as soon as possible, the one year village comparison was used. The comparative analysis of improving village over time was included as a check on the one year analysis. Time and money constraints prevent us from taking a larger sample of villages and farmers or from doing a participant observation where information is collected on a daily or weekly basis. We also felt that with our limited objective of evaluating the economic impact that the survey approach was adequate. A larger sample would have made us more confident in extending the results to other areas while participant observation would have improved our data particularly for such things as labor use and nutrient content of fertilizer.

The comparison of the same village over time will provide some important checks on uncontrolled variables such as leadership. Such variables are difficult to control when making comparisons between villages. There are always subtle differences among villages which cannot be controlled. These differences can equip one village for progress and not another. Thus some of the changes observed in the improved villages compared to the control villages may be due to uncontrolled variables and cannot be attributed to the irrigation improvement. However, adoption rates of inputs before and after the project indicate that the control and improved villages had about the same willingness to use modern inputs (see table 1).[1/] In addition, the

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1/ The adoption rates for the improving villages is somehwat lower since one of the villages was more backward than the others. It was felt that if the program could work in this backward village it could work in most villages in the irrigated area.

TABLE 1

Percentage of Sample Farmers Using Selected Inputs

Year	HYV's*	Fertilizers	Pesticides
	. . . . (Improved Villages)		
Before 1964	2	12	8
1964-65	3	32	10
1965-66	7	48	18
1966-67	30	68	40
1967-68	57	82	62
1968-69	78	88	73
1969-70	87	92	77
1970-71	95	98	78
	. . . . (Control Villages)		
Before 1964	0	11	0
1964-65	5	23	5
1965-66	9	42	11
1966-67	17	52	17
1967-68	52	82	45
1968-69	75	97	63
1969-70	81	99	63
1970-71	86	100	64
	. . . . (Improving Villages).		
Before 1964	0	6	6
1964-65	2	12	8
1965-66	5	17	11
1966-67	8	33	18
1967-68	39	50	29
1968-69	56	67	52
1969-70	67	77	61
1970-71	71	80	62

* Before 1966-67 adoption rates refer to locally improved varieties and not what are considered HYV's such as TN-1 and IR-8.

interest shown by other villages in the irrigation improvement indicates that the economic benefits are real, sizeable, and transferable.

C. Data and its strengths and weaknesses.

The data collected can be grouped under five headings: (1) general information about the district: rainfall, topography, soil, cropping patterns, etc.; (2) resource availability and characteristics of the sample farms: farm size, area irrigated, family size, value of animals, type of equipment, etc.; (3) physical input-output data for the sample farms: yields, fertilizer applied, pesticides used, labor time, etc.; (4) data on the prices of inputs and outputs from the sample farms; and (5) cost information from the district staff concerning the irrigation improvement.

The general information obtained for the district is accurate enough to provide a picture of the overall study area. The other information obtained from the district staff, the cost of the irrigation improvement, is quite accurate although some management and training costs may have been omitted. These costs are based on actual wages which may be less than the opportunity cost for the skilled labor. The data collected from the sample farmers has a varying degree of accuracy due to the recall problem. Resources available such as acres of land, and family labor were well known although some of the larger farmers may have understated farm size. On the other hand, when it came to determining how many hours of family labor were used during a given farming operation, such as weeding or harvesting, the farmers had difficulty remembering. Purchased inputs such as fertilizer were recalled fairly well in terms of cost and quantity. The distribution of fertilizer among fields was recalled less well. The recall of varieties and adoption rates was surprisingly good. Finally, the price data could be checked among

farmers and were found to be fairly consistent.

In the second interview some of the larger operators (7.5 acres and above) may have underestimated yields as well as acres cropped. The state had imposed an income tax on farm income and large operators seemed a little concerned that the state officials might get their hands on our data. This may explain why the medium size farms reported higher yields than the large farms for high yielding rice varieties even though the large farms reported using more fertilizer (see tables 2 and 3).

A further weakness in the study was that water flows could not be measured. Thus, the availability of water could not be accurately checked. Observations during the survey did not show any obvious differences in water availability among villages. Yet differences in water availability to villages may account for some of the differences in production found among villages.

Another problem with the study was that the final stage has not been completed. The improving villages have not been resurveyed and the results checked with the one year comparison. The work was not completed for a number of reasons. The foremost was the Ford Foundation's unfortunate dumping of its technical assistance program in India starting in late 1971. A resurvey could still be done although the time lapse has been six years. This length of time allows change in too many uncontrolled variables and would make comparisons difficult. The best time for the second survey would have been 1972-73 or 1973-74.

Finally more accurate data could have been collected if there had been time to establish a record keeping project. Much of the data needed could have come from good farm record books. However, farm record projects take several years to establish and have met with only limited success in India.

TABLE 2

Mean Rice Yields on Sample Farms in the Three Types of Villages, 1970-71[a]

	Local Varieties						High Yielding Varieties		
	Wet Season			Dry Season			Dry Season		
Farm Size	Improved	Control	Improving	Improved	Control	Improving	Improved	Control	Improving
Small[b]	8.3	5.9	3.3	13.4	9.2	8.9	16.2	12.5	13.8*
Medium	10.1	6.2	4.2	13.3	9.7	11.6**	19.4	14.1	14.6
Large	9.3	6.6	5.7	13.4	10.1	9.5	18.9	14.2	16.2
All Farms	9.2	6.2	4.3	13.4	9.7	9.9	18.4	13.6	15.2

[a]A quintal equals 100 kgs. or 4.9 bushels in rough rice.

[b]Control and improving villages have significantly lower yields at the one to five percent level except where indicated as follows:
* 10 percent level of significance
** 15 percent level of significance

TABLE 3

Mean Fertilizer Applications in Total Nutrients for the Three Types of Villages, 1970-71

Farm Size	Local Varieties						High Yielding Varieties		
	Wet Season[a]			Dry Season			Dry Season		
	Improved	Control	Improving	Improved	Control	Improving	Improved	Control	Improving
	---------kgs. per acre------								
Small[b]	36	28**	10	46	41***	27*	64	44	50**
Medium	37	32***	21	64	37	29	79	62*	54
Large	41	41***	28**	68	44	31	90	61	64
All Farms	38	33**	20	60	40	29	80	56	58

[a]So little acreage of high yielding rice was grown during the wet season that only local varieties are shown.

[b]Control and improving villages have significantly lower fertilizer applications at the one to five percent level except where indicated as follows:

* 10 percent level of significance
** 15 percent level of significance
*** significant only at some lower level

D. Technology and policy implications.

The sample of villages was taken from the same development block where climate, land, and culture were quite similar. The high temperatures of 103° to 117°F occur in May which is just before the wet season. The average rainfall is 1671 mm. which falls primarily between June and September. In a normal year this would be enough rain for a good crop of rice. The cultivated lands are divided into four broad types according to their location; Att (uplands), Mal (the slopes), and Berna and Bahal (low lands). The sample was selected so that we could test statistically the effect of land type and farm size on fertilizer use, yields and the benefits from irrigation improvement. Information was also obtained on adoption rates and acreages of high yielding rice varieties (HYV's) to determine if they were affected by the improved irrigation.

The policy implications of the study are clear for the Hirakud command area: expand the program of improving village irrigation systems. Completing only nine villages a year is not enough given the high net returns from the program of $77 to $115 per acre [Easter, 1977].[2/] Two major problems prevent rapid expansion. First there is a lack of technically trained Indians willing to work in villages who can do the survey work necessary to get the ditches running in the right direction. They must also work with the farmers in deciding on where the ditches should be dug and help them get the ditches and other structures in place. Second, the funds and positions to employ these technically trained Indians may not be available. The funding problem might be overcome by charging

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[2/] Technical assistance costs were valued at the existing government wage rates. If an additional charge was included to account for the opportunity of this technical assistance, it would not significantly change the program's profitability.

farmers a modest fee for the technical service. With these high benefits from the service it may be possible to collect up to $5 per acre. On the other hand, once some of the villages have obtained a free service it is difficult to charge others. This would be similar to the difficulty the U.S. government has had in getting SCS to charge for their technical services. The success of the program should help encourage the state to create some of the needed positions on the district staff. However, as we all know, things change very slowly in the government bureaucracy.

The same type of irrigation improvement should be expanded and tested in other irrigation systems where numerous farmers are irrigated from one outlet. It was expanded to one small village in Raipur district in Madhya Pradesh just west of Sambalpur. This is a village irrigated by a small tank when water is available. Thus it is a much different system than the one in Sambalpur. Construction was started in 1971 and completed in 1972. The costs were much higher, $120 per acre, due to canal linings and the digging of a major drain.

We did a before project survey of the Raipur village to provide a bench-mark for evaluating the program. Again we were not able to do the follow-up survey for the same reasons as in Sambalpur. However, by applying Sambalpur yield increases to Raipur we did get an idea of the possible returns from such a project. With two crops a year even this high cost project would pay a return of over 20 percent. In contrast, if water is not available for a second crop the returns would not reach 10 percent. For a one crop economy a lower cost alternative should be tried.

The improved irrigation in Sambalpur was a major factor in increasing the acreage planted to high yielding varieties during the dry season.[3/]

3/ Because of insect problems very little HYV's were grown during the monsoon or wet season.

Seventy-two percent of the acreage cropped on the sample farms in the improved villages were planted to HYV's while only 54 percent and 41 percent were planted to HYV's in the control villages and the improving villages respectively. Higher uses of fertilizer went along with both improved irrigation and HYV's. This emphasizes the complementarity between controlled irrigation, HYV's and fertilizer use. Of course, this creates some problems in estimating a production function for rice. We essentially ended up estimating separate functions for local varieties, HYV's and for each set of villages.

The irrigation improvement in Sambalpur did allow the improved villages to irrigate more acreage as cropland irrigated increased from 84 percent to 97 percent of total cropland. In contrast the cropping pattern was not changed. Rice is still the major crop in both seasons accounting for 97 percent of the cropped area in the wet season and 99 percent in the dry season. One reason for the stable pattern may be that the farmers did not have enough time to adjust to the new cropping alternatives. For example one of the improved villages not surveyed was growing vegetables. Another reason is that the more assured water supply may have made it unnecessary for farmers to grow crops which require less water such as wheat. Wheat was one of the crops the district extension people were trying to get farmers to grow during the dry season since it required much less water and had a good market. However, the farmers do not have much experience in growing wheat and the planting time for wheat is very critical for good yields. Finally, the price of water did not encourage the shift from rice to less water intensive crops. At the time of the study the water charge was only one rupee per acre more for growing rice as compared to wheat. This was

being changed in 1972 and will be an interesting factor to analyze in any follow-up study.

Although historically the Bahal land has been the most productive, fertilizer use and yields were not significantly different among land types. The primary difference among land types was the percentage of rice planted to high yielding rice as compared to local varieties (see table 4). The Bahal land had the highest percentage of high yielding rice followed by Bernal land and Mal land. This fits the pre-irrigation productivity of these lands. However, in general the analysis suggests that the irrigation has substantially reduced the differences in productivity among these three land types [Easter, 1977].

The effect of farm size was not clear in the improved villages. In terms of yields per acre the medium sized farms did as well or better than small or large farms (see table 2). Yields of the medium sized farms were significantly higher than those of the small farms at the 5 percent level except for local varieties in the dry season. Large farms also have significantly higher yields than small farms at the 5 percent level for HYV's. On the other hand, fertilizer use increased by farm size in all cases. In the control and improving villages yields and fertilizer generally increased slightly with farm size.

Returns per acre were not much different between medium and large farms while small farms did have the lowest returns per acre. Of course, total returns for large farms would be the highest because they have more acres. Even so as indicated earlier none of the large farms cultivated over 30 acres.

One conclusion that can be drawn from the study is that once a farmer has 4 to 7 acres he can make as much per acre as farms of 10 to 30 acres. With two crops a year this is a good income for a farm family in India.

Table 4. Percentage of High Yielding Rice Planted in the Dry Season by Land Type and Village 1970-71

	Land Type*		
	Mal	Berna	Bahal
	percentages		
Improved Villages	63	74	90
Control Villages	36	61	70
Improving Villages	25	45	66

*Not enough Att land was cropped to include it as part of the analysis.

Two interesting factors were discovered during the field work and discussions with the district staff. One was that farmers from the irrigated coastal region of Andhra Pradesh had moved to Sambalpur in the early years of the project. They purchased land and put the irrigation water to good use. It would be interesting to know how much these Andhra farmers helped improve the use of irrigation water. Did their irrigation serve as a demonstration for the Sambalpur farmers? The lack of data over time makes it difficult to trace out any such impacts.

Second a number of farm laborers purchased low valued Mal land during the first years of the Hirakud project. This land is now almost equal in value to the low lands and has substantially increased these laborers position both socially and economically. I would like to see a study to determine how widespread these purchases by the laboring class have been and what conditions made these purchases possible? It may be that the purchases only occurred in a few villages and that it was just a chance happening.

In conclusion several policy observations can be drawn concerning the organization of irrigation projects. First is that farmers should be involved in organizing and operating the systems at the village level. One of the reasons for the success of the Sambalpur program of irrigation improvement was the village approval of the project before it was started and the good working relationship between the extension staff and the farmers. The engineers actually walked through the fields with the farmers looking at alternative routes for the field channels. However, it is also clear that the farmers definitely needed the technical assistance.

Second, in the early stages at least, the irrigation improvement should be low cost and simple. This is an important criterion the district staff was using. They felt that this allowed them to do more villages and get the

farmers directly involved. By keeping the program simple farmers could readily understand what was being done and why.

Third, if possible, the program should be structured so that farmers are actually involved in the construction. Either they have to contribute funds or labor. For the Sambalpur projects the farmers had to dig the field channels.

Finally the correct identification of the problem is critical in irrigation studies. Is the water distribution problem at the field or terminal level or is it at the secondary or primary level of the system? In Sambalpur the first problem was at the terminal level because of the large numbers of farmers served from one outlet.

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