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PRIVATE AND COMMERCIAL PROFITABILITY FROM INVESTMENT IN IRRIGATION: A CASE STUDY OF THE WESTERN GANDAK CANAL PROJECT

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A. *Introduction*

The importance of irrigation for the development of agriculture was realized from the very inception of planning in India. Accordingly, huge investment has been made for development of irrigation through construction of various types irrigation projects. One such project taken up during the Second Five Year Plan was the Western Gandak Canal Project in eastern Uttar Pradesh. Assessing profitability of investment in this project is important, first, because no ex-post evaluation study has been made of a canal irrigation system in a high-rainfall region like eastern Uttar Pradesh, which is known for being backward and poor. Secondly, the results of a preliminary study [5] based on secondary data from Gorakhpur and Deoria districts, which fall in the command area of the project, showed that expansion of irrigation in the 1960s in these two districts had limited impact on the agricultural economy of these districts. The present project, the Main Western Gandak Canal Project, started providing irrigation to the region in 1972. In the following years there has not been any significant change in the cropping pattern, irrigated area, and crop yields. Since these are the basic variables which determine the profitability of an irrigation project, one can hardly overemphasize the need for conducting an ex-post evaluation study of the project. In the present paper, an attempt has been made to investigate the private and commercial profitability of investment made in the project.

The private profitability depends upon direct costs and benefits incurred and received by the private interests expected to benefit from the project, i.e., the farmers. The relevant prices to be used for assessment of the private costs and benefits are the prices of inputs and outputs paid and received by the farmers. In analyzing commercial profitability, the money value of costs and benefits of the public investment project are calculated from the society's standpoint, where the public project's goal is assumed to be commercial or revenue earning. The

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relevant prices are the unadjusted market prices of the inputs and outputs of the project. The irrigation part of the project was completed by the Irrigation Department, Government of Uttar Pradesh, while the Command Area Development part of the project was implemented by the Gandak Command Area Development Authority, Gorakhpur, Government of Uttar Pradesh. Hence, the commercial profitability aspect is pursued by the state government representing the social side that is expected to benefit from the project.

The prime beneficiaries of the Gandak project are the farmers in the project region. It is imperative, therefore, to ascertain the private profitability of the project to the farmers. If the private profitability turns out to be marginal or even negative, it would mean that farmers have not behaved as proposed and expected by the project authorities. This would indicate the need for changing the relevant government policies and programmes accordingly. For instance, if farmers benefit little or even negatively, the government may like to reduce the water charges, provide subsidies on inputs like fertilizers, or offer credit at a cheaper rates and so on. On the other hand if the project were to show high private profitability, it would reflect the scope for mobilizing resources from the farmers by means of levies, taxes, enhanced water rates, etc. for the public sector.[1]

Since the investment cost of the project is largely met by the government or the public agencies and not by the farmers, it is desirable at the same time to see what the project's private profitability would be if the farmers as a group were to meet this cost or the government as their representatives were to meet this cost by borrowing the requisite funds from a financial institution like the Asian Development Bank or the World Bank at a certain rate of interest. To evaluate the project from this angle, we designate a commercial evaluation. Although we are well aware that the present project is not strictly a public commercial project as the benefits of increased agricultural production do not accrue directly into the hands of the government. Where the commercial profitability as understood in this study is far below that of the farmers' private profitability, it would be difficult to pay back the investment funding at the stipulated rate of interest. Transferring a part of the farmers' benefits for these payments might help improve the position, but the worthiness of the project would remain doubtful so long as commercial profitability measured by the project's internal rate of return is lower than the rate of interest at which the investment funding had been chosen to be borrowed. The final choice, therefore, rests on the project's economic and social profitability.

[1] S. N. Mishra and John Beyer [3], have given four important reasons for conducting a survey on the private profitability of the project. First, private profitability shows whether individuals or institutions involved in the project can realistically be expected to take the action which the project envisages. Secondly, it can be examined whether government action on prices affecting the project might be warranted particularly where there is a large divergence between social and private profitability. Thirdly, it will show the government what its income would be in the form of revenue from the project. Fourthly, in the case of joint-sector projects involving private and public investment together, calculation of private profitability is necessary for the project choice as it can be selected only after both the private and social profitabilities are positive.

B. *The Project and Sources of Data*

The Gandak Canal Project is a major irrigation project designed to exploit the water resources available in the eastern part of India along the Himalayan foothill plains covering parts of Uttar Pradesh, Bihar, and Nepal. The project was designed and approved by the Planning Commission in 1961, its main objective being to provide an assured and controlled supply of irrigation water to the command area of the project. Initially, the total cost of the project for Uttar Pradesh was estimated at Rs.151.5 million. This cost was revised in 1966, 1978, and again in 1983. The respective cost estimates were placed at Rs.503.8 million, Rs.855.8 million, and Rs.1,034.5 million [9, 1984–85 and 1986–87 editions].

The project consists of a barrage constructed across the Gandak River at Valmikinagar on the Indo-Nepal border at about 1,500 feet below the existing Tribeni Canal Head Regulator, located in the territory of Nepal. Water from this barrage is diverted into three main canals, viz., the Western, Eastern, and Nepal Western Gandak Canal flowing through the states of Uttar Pradesh, Bihar, and Nepal respectively. The scope of the present paper is limited to the Main Western Gandak Canal (with a capacity of 15,800 cusecs) including the Command Area Development Project which was started in the command area in 1972–73, when the Gandak Canal started providing water to the Gorakhpur and Deoria districts of Uttar Pradesh. The total area of the command is estimated to be 539,000 hectares with a cultivable area of 443,000 hectares. The Command Area Development Project was introduced for speedy and optimum utilization of the irrigation potential created. The project consisted of the construction of on-farm development (OFD) works[2] and also the provision of infrastructure facilities like construction of link roads, supply of basic inputs like high-yielding varieties of seeds, fertilizers, etc.

The public investment and operational cost of project were collected from the project records made available by the Gandak Project office, the Gandak Command Area Development Authority located at Gorakhpur, and the *Draft Sixth Five Year Plan, 1980–85, Command Area Development, Uttar Pradesh.* The quantitative information needed for estimation of benefits was collected by the author through a sample survey of four villages representing four major soil groups in the command of the project. A census was conducted of the four villages covering all the 450 households.[3]

C. *Method of Approach*

One of the major problems in project evaluation concerns assessing the income benefits of an investment project. Traditionally, two approaches have been adopted to solve this problem: (i) a "before and after the project" approach and (ii) a "with and without the project" approach. In the present case, we shall be concerned with the estimation of income benefits resulting from investment in an irrigation project. In the first type of approach, the pre-project status of the

[2] OFD works includes construction of field channels, field drains, land levelling, etc.

[3] See Appendix for basic data of sample households.

beneficiaries at point of time is compared with their post-project status at another point of time. In the second type of approach, "with the project" situation is compared with "without the project" situation over the whole life time of the project. The former approach suffers from a number of limitations. First, it fails to consider the whole income benefit stream and its present value sum. Secondly, due to its focus on point comparison, it fails to take into account income changes that may occur in the absence of the project, for instance an increase in agricultural production resulting from the adoption of high-yielding varieties of seeds and the application of fertilizers in rain-fed conditions. Finally, the use of a "before and after the project" approach requires a bench-mark survey of the relevant aspects of a farmer's economy before the project is actually executed and another survey after the project has come into operation. As in the present case it generally happens that no bench-mark survey is conducted in the project region before the start of the project. Because of these limitations to the first approach, I have used the "with and without the project" approach for the purpose of estimating income benefits from the project using the survey data on farm inputs and outputs.

In this study the situation "without the project" refers to unirrigated farms in the sample villages. An alternative to this would have been to have a control sample outside the project area but adjacent to the command area of the project with comparable biological and environmental conditions. But given the problems of time and resources to a lone research worker, this method was not possible to use. For this reason the unirrigated farm conditions do not reflect those of a control area in the strict sense. This is because introduction of canal irrigation does have some external effects on the cropping pattern and crop yields on unirrigated farms while at the same time affecting their profitability. Clearly, therefore, use of unirrigated farm conditions in the project area to represent the situation without the project tends to underestimate the net benefits accrued to the farmers. Benefits in both with and without situations are net of costs of cultivation. These benefits have been estimated on a per acre basis and total benefits have been arrived at by multiplying these benefits by the area irrigated during each year.

In the assessment of private and commercial profitability, the relevant costs and benefits have been estimated at the ruling market prices. It should be noted that private profitability of investment in canal and public tubewell irrigation systems as these affect cultivation is different from the same in the case of private tubewells or the traditional methods of irrigation. In the former case the cost of irrigation is just the water charges paid by the farmers to the government, while in the latter case the cost of irrigation is comprised of investment and working expenses of the irrigation system. However, for the non-owner users of private tubewell irrigation, private profitability would once again be exclusive of the investment and operating cost of the irrigation system. It needs no saying that in the case of canal and public tubewell irrigation systems, investment and working expenses of the project area met by the government and hence these do not as such constitute the cost of irrigation to the farmers.

TABLE I

ESTIMATES OF INCREMENTAL BENEFITS PER ACRE

(Rs.)

Farm-size Group[a] (1)	Irrigated Area			Unirrigated Area			Incremental Benefits Due to the Project (8)
	Gross Value of Output (2)	Cost of Culti-vation (3)	Net Value of Output (4)	Gross Value of Output (5)	Cost of Culti-vation (6)	Net Value of Output (7)	
I	1,136.4	430.0	706.4	961.3	446.4	514.9	191.5
II	1,197.6	450.9	746.7	905.0	365.1	539.9	206.8
III	1,306.8	513.2	793.6	1,103.4	492.1	611.3	182.3
IV	1,316.8	620.6	696.2	1,104.0	489.7	614.3	81.9
For all farms	1,228.5	490.0	738.5	1,027.2	456.0	571.2	167.3

[a] Group I: farmers owning up to 2.50 acres. Group II: farmers owning 2.51–5.00 acres. Group III: farmers owning 5.01–10.00 acres. Group IV: farmers owning 10.01 and above acres.

The analysis of private profitability to the farmers is for the year 1978–79, the year for which data on the farm economy was collected during my survey. Since the farmers of the project area are not a homogeneous group, I did private evaluations separately for farmers in different size groups. Further, this was done for sample farmers only assuming that the results of the evaluation would apply to all farmers in the respective groups throughout the whole project area.

D. *Estimation of Farmer Benefits and Costs*

As mentioned earlier benefits accruing from the project have been calculated by using the "with and wtihout the project" approach. Income benefits in both situations are net of costs of cultivation. The cost of cultivation includes expenses for human and bullock labor, seeds, fertilizers, farmyard manure, tractor hours (if used), insecticides and pesticides, repairs and maintenance charges on farm implements and bullocks, depreciation on farm implements machinery and draft bullocks, interest on borrowed funds for the purchase of inputs like fertilizers, and finally land revenue charges. The cost and output benefit estimates on a per acre basis for different groups of farmers are given in Table I.

It is noteworthy that the gross value of output per acre on canal irrigated farms shows a rising trend with the increase in farm size. This is in contrast with the widely accepted finding in Indian agriculture of an inverse relationship between farm size and productivity per acre, a relationship which recently has been found to be breaking down following the "green revolution."[4] A possible explanation for the direct relationship between size and productivity can be found in the cropping pattern of the farmers and the corresponding yield per acre. These are

[4] For a review of early literature on farm size and productivity relationship, see Bhagwati and Chakravarty [1]. For recent changes in the relationship, see Saini [4].

TABLE II

CROPPING PATTERN BY FARM-SIZE GROUP

Type of Crop	Farm-size Groups								For All Farms	
	I		II		III		IV			
	Irri. % to GAS	Unirri. % to GAS	Irri. % to GAS	Unirri. % to GAS	Irri. % to GAS	Unirri. % to GAS	Irri. % to GAS	Unirri. % to GAS	Irri. % to GAS	Unirri. % to GAS
Early paddy	33.5	17.5	39.2	6.5	37.3	2.9	38.6	1.9	36.9	7.6
Late paddy	5.4	47.6	4.1	28.6	2.9	32.5	2.4	14.1	4.0	29.9
Maize	—	1.1	—	2.1	—	3.5	—	1.0	—	1.7
Jowar (sorghum)	—	0.8	—	2.5	—	2.5	—	0.9	—	1.4
Bajra (pearl millet)	—	0.9	—	7.1	—	4.2	—	4.7	—	3.9
Wheat	52.3	0.2	43.2	—	49.5	—	47.2	—	48.2	0.1
Wheat & *toria* (mustard)	4.8	—	2.6	—	—	—	—	—	2.2	—
Barley	0.1	0.2	0.2	2.9	—	—	—	—	0.1	0.6
Total cereals	96.0	68.3	89.3	49.7	89.7	45.6	88.2	22.6	91.4	45.2
Arhar (pigeon pea)	—	1.4	—	3.0	—	7.7	—	3.5	—	3.5
Peas	0.3	0.3	0.9	—	1.3	—	0.7	—	0.7	0.1
Gram	0.8	—	0.9	1.8	2.8	0.3	3.5	0.2	1.9	0.4
Gram & *toria*	—	0.7	0.7	4.9	0.9	1.9	1.9	—	0.8	1.3
Masoori (lentil)	0.1	0.2	0.2	1.5	0.1	0.5	—	1.0	0.1	0.7
Total pulses	1.2	2.6	2.7	11.2	5.1	10.4	6.1	4.7	3.5	6.0
Potatoes	0.2	0.3	0.3	—	0.2	—	1.5	—	0.5	0.1
Toria	—	—	0.2	0.6	0.5	2.2	—	7.5	0.2	3.1
Sugarcane planted	2.2	19.6	4.6	20.0	3.6	28.7	3.3	33.5	3.3	26.2
Sugarcane ratoon	0.4	9.2	2.8	18.5	0.6	13.1	0.5	31.7	0.9	19.4
Other nonfood crops, berseem, etc.	—	—	0.1	—	0.3	—	0.4	—	0.2	—
Total nonfood crops	2.6	28.8	7.5	38.5	4.5	41.8	4.2	65.2	4.4	45.6
Total crops	100	100	100	100	100	100	100	100	100	100

Notes: 1. Irri.=Area irrigated, Unirri.=Area unirrigated, and GAS=Gross area sown.
2. For farm-size group I–IV, see note to Table I.

TABLE III

YIELD PER ACRE OF MAJOR CROPS

(Quintal)

Grops	Farm-size Groups							
	I		II		III		IV	
	Irri-gated	Unirri-gated	Irri-gated	Unirri-gated	Irri-gated	Unirri-gated	Irri-gated	Unirri-gated
Early paddy	9.2	8.9	11.5	7.3	11.6	10.0	12.3	11.3
Late paddy	8.9	9.0	7.3	7.5	9.6	8.2	9.7	10.2
Wheat	9.1	—	9.2	—	10.6	—	11.2	—
Sugarcane planted	144.2	150.3	166.3	147.0	156.3	175.2	168.6	167.1
Sugarcane ratoon	101.0	105.1	118.9	97.2	100.0	95.3	125.0	93.1

Notes: 1. One quintal=100 kg.
2. For farm-size group I–IV, see note to Table I.

presented in Table II and Table III respectively. A look at these tables makes it evident that in the case of canal irrigated farms, paddy and wheat are the two crops which account for 95.9 per cent, 89.1 per cent, 89.7 per cent, and 88.2 per cent of the gross area sown in farm-size group I, II, III, and IV respectively.[5] Excluding the marginal farmers (size group I) it shows that the proportion of area under these crops remains almost constant over different size groups of farmers. Thus, with no considerable variation in the cropping pattern across farm-size groups, the differences in productivity per acre are essentially the differences of yields obtained by farmers in differing size groups. This is confirmed by a reading of Table III.

In the case of unirrigated farms also, the direct relationship holds if we exclude the marginal farmers from the picture. Unirrigated paddy and sugarcane are the main crops on these farms, accounting for 93.9 per cent, 73.6 per cent, 77.2 per cent, and 81.2 per cent in size group I, II, III, and IV respectively. Leaving aside the marginal farmers in group I, the area under sugarcane shows an increasing trend with farm size.

We see from Table I that the net value of crop output per acre on irrigated farms increases with farm size up to group III, i.e., up to medium-size farmers, and falls thereafter. This happens in spite of the fact that the cost of cultivation per acre also increases with the increase in farm size. The cost increase in relative terms is, however, lower up to medium-size farmers, but it becomes far too large when we reach the large-size group. In Table IV we give the structure of cost per acre for the different groups. It is evident that large farmers incur relatively higher expenditures on chemical fertilizers and hired human labor as compared to other size groups. Table I also indicates that the net value of output per acre on unirrigated farms shows an increasing trend. It is the lowest in the case of marginal farmers as these farmers incur relatively more expenditure on farm inputs. It is the highest in the case of large-size farmers, though it is marginally

[5] For farm-size groups see note to Table I.

TABLE IV

STRUCTURE OF COST PER ACRE ON CANAL IRRIGATED AND UNIRRIGATED FARMS

(Rs.)

Inputs	Farm-size Groups								For All Farms	
	I		II		III		IV			
	Irri-gated	Unirri-gated	Irri-gated	Unir.i-gated	Irri-gated	Unirri-gated	Irri-gated	Unirri-gated	Irri-gated	Unirri-gated
Tractor hours	7.6	2.8	1.8	3.0	13.2	5.3	67.2	48.0	21.4	19.2
BLD[a] owned	43.4	46.9	70.1	56.0	69.3	76.7	76.4	69.6	63.2	61.7
BLD hired	38.0	40.2	11.0	17.3	9.1	7.4	25.8	2.2	22.6	17.1
Thresher hours	—	—	1.2	—	6.5	—	0.8	—	1.7	—
HLD[b] family	111.1	126.8	125.2	91.4	108.2	93.4	75.1	77.6	99.6	97.6
HLD hired	35.9	38.0	46.8	13.4	75.7	79.7	96.8	85.7	61.0	59.0
Seed	37.2	51.8	39.1	68.6	37.2	72.5	39.3	65.4	38.2	63.0
Urea fertilizer	60.9	46.8	58.0	34.9	71.4	49.8	75.2	41.5	65.6	43.5
NPK fertilizer	62.0	49.6	61.1	35.1	83.7	63.7	77.4	42.6	69.7	47.3
Farmyard manure	6.4	9.2	6.8	5.8	6.0	6.1	8.2	5.6	6.9	6.8
Insecticides & pesticides	0.3	1.7	2.9	3.9	3.8	3.8	0.6	3.9	1.7	3.2
Fixed costs	27.4	32.2	26.8	35.7	29.2	33.8	78.0	47.8	38.5	38.5
Total cultivation costs	430.2	446.0	450.8	365.1	513.3	492.2	620.8	489.9	490.1	456.9
Irrigation charges	39.9	—	47.7	—	41.6	—	41.8	—	42.7	—
Total cost	470.1	—	498.5	—	554.9	—	662.6	—	532.8	—

Note: For farm-size group I–IV, see note to Table I.

[a] Bullock labor days.

[b] Human labor days.

TABLE V

PRIVATE BENEFIT-COST RATIOS

Farm-size Groups (1)	Additional Benefits Due to Irrigation per Acre (Rs.) (2)	Area Irrigated (Acres) (3)	Total Additional Benefits (Rs.) (4)	Irrigation Fee Paid by the Farmers (Rs.) (5)	Annual Benefit-Cost Ratio, (4)/(5) (6)
I	191.5	275.8	52,815.7	11,009	4.79
II	206.8	228.4	47,233.1	10,893	4.33
III	182.3	175.4	31,975.4	7,298	4.38
IV	81.9	211.4	17,313.7	8,828	1.96
For all farms	167.3	891.0	149,064.3	38,028	3.92

Note: For farm-size group I–IV, see note to Table I.

different compared to the net yield obtained by medium-size farmers. The net additional income benefits per acre due to irrigation are given in the last column of Table I. These benefits have been estimated by deducting the net value of output per acre on unirrigated farms from the net value of output per acre on irrigated farms in respect of each farm-size group. It is clear from Table I that, leaving aside the marginal farmers, the net income benefit shows a declining trend with the increase in farm size. This behavior may be explained by comparing the gap in the net value of output per acre on irrigated and unirrigated farms over different size groups. In the case of marginal farmers, whereas the net value of output per acre on irrigated farms is Rs.706.4, it is Rs.514.9 per acre on unirrigated farms, the former being over 37 per cent higher. Similarly, in the case of other size groups, the value of net yield on irrigated farms is higher by about 38 per cent, 30 per cent, and 13 per cent respectively as we move up the size groups. Clearly, as we move up the size groups, this gap is reduced, and the additional income benefit per acre from irrigation declines. Looked at from a different angle, this gap also implies that given the present cropping pattern and yields, the additional income benefit to farmers as a whole could increase over 29 per cent if the whole area were to come under irrigation. The additional total income benefits have been obtained by multiplying the additional income benefits per acre with irrigated crop area for the respective groups of farmers. These are presented in Table V, column (4).

As mentioned earlier, in the case of canal and public tube-well irrigation systems, investment and working expenses of the project are not included in the cost component while calculating the cost of irrigation water for the farmers. These costs are borne by the government and the only cost to the farmers is the irrigation charges. If government imposes betterment levies after the project comes in operation, they would also be included in the farmers' cost for irrigation water. In the project under evaluation no such levies have been imposed so far. Therefore, as against the additional benefits accruing from irrigation, irrigation charges are the only cost to the farmers. I have included in the total cost the

actual irrigation charges paid by the farmers. These irrigation charges for the different groups of farmers are given in Table V, column (5).

E. *Farmer's Private Profitability*

Once we have calculated the project costs and benefits of the project, we may use the benefit-cost ratio, net present value, or internal rate of return to decide whether the investment is profitable or not from the private standpoint. For an individual project, if it is worthy of selection on the basis of one criterion it will be worthy on the basis of the other criteria also. This is because if benefit-cost ratio at a given rate of discount is greater than one, the net present value of benefits will be positive and the internal rate of return will be greater than the rate of discount. In the present case, given the cropping pattern, crop yields and area under cultivation, the annual benefits and costs of irrigation accrued and incurred by the farmers remain constant throughout the expected economic life of the project. Accordingly, we obtain a constant stream of farmer irrigation benefits and costs. In such a case the benefit-cost ratio based upon undiscounted sums of benefits and costs remains the same as in the case when it is based upon discounted sums of benefits and costs. However, as the rate of discount is increased, the net present value of benefits declines, but beyond a point the rate of decline becomes very slow, so much so that the former never reaches zero. Accordingly, this implies by definition that the internal rate of return becomes asymptotic to the X-axis, therefore, indeterminate. After declining drastically with the increase in the rate of discount, the net present value of benefits declines extremely slowly above the 50 per cent rate of discount. This was observed in respect of each farm-size group as also when all the farms are taken together.

In view of the above, I preferred to present the farmer's benefit-cost ratios in Table V based on undiscounted sums of benefits and costs. The benefit-cost ratio is highest (4.79) in the case of marginal farmers. It implies that marginal farmers derive the maximum income benefits from one rupee worth of irrigation cost. In other words, for every one rupee spent on irrigation water, marginal farmers obtain Rs.4.79 worth of income benefits. On the other hand, the large farmers derive the least benefits from one rupee spent on irrigation water, i.e., only Rs.1.96. It follows that marginal farmers utilize irrigation water most efficiently and the large farmers least efficiently. The small and medium-size farmers' efficiency is fairly close to that of the marginal farmers, their irrigation income benefits being Rs.4.33 and Rs.4.38 respectively for each rupee of irrigation cost. There is likely to be an increase in the area irrigated in future years as a result of the project, but 100 per cent irrigation appears to be only a theoretical possibility, because there is always some unirrigated area devoted to cultivating dry crops like *arhar* (pigeon pea), maize, and *bajra* (pearl millet). These crops do not require irrigation. On the other hand if the percentage of area irrigated were to increase in each group of farmers, it would be necessary to obtain the projected irrigated area over the years for each of the groups.

I have preferred to abstain from such an exercise, the reason being, that such an exercise will simply reveal that the net present value for each size group of farmers will be higher at the given rate of interest compared to the values given

TABLE VI

ESTIMATES OF NET PRESENT VALUE AND BENEFIT-COST RATIOS BY FARM-SIZE GROUP AT DIFFERENT RATES OF DISCOUNTS

Rate of Discount (%)	Farm-size Groups								For All Farms	
	I		II		III		IV			
	NPV (Rs. 1,000)	B/C Ratio	NPV (Rs. 1,000)	B/C Ratio	NPV (Rs. 1,000)	B/C Ratio	NPV (Rs. 1,000)	B/C Ratio	NPV (Rs. 1,000)	B/C Ratio
0	1,254	4.80	1,090	4.34	741	4.38	255	1.96	3,333	3.92
5	675	4.80	587	4.34	398	4.38	137	1.96	1,793	3.92
10	434	4.80	377	4.34	256	4.38	88	1.96	1,152	3 92
15	316	4.80	274	4.34	186	4.38	64	1.96	839	3.92
20	250	4.80	217	4.34	147	4.38	51	1.96	664	3.92
25	209	4.80	181	4.34	123	4.38	42	1.96	555	3.92
30	181	4.80	157	4.34	107	4.38	37	1.96	481	3.92
35	161	4.80	140	4.34	95	4.38	33	1.96	428	3.92
40	146	4.80	127	4.34	86	4.38	30	1.96	389	3.92

Notes: 1. NPV=Net present value, B/C ratio=Benefit-cost ratio.
2. For farm-size group I–IV see note to Table I.

in Table VI. This will just reinforce the high private profitability of the project.

According to the information available from the project progress report, expenditure incurred by the Command Area Development Authority on completion of OFD works up to the year 1977–78 was to be directly recovered from the beneficiary farmers. However, details of repayment schedule etc. were not available. Financing of OFD works from the year 1978–79 onwards was proposed to be done through financing institutions. As per the information available from the project records, it would cost about Rs.200 (1978–79 prices) to complete OFD works on an acre of land. Assuming that this amount was to be recovered from the farmers over a period of ten years with an interest rate of 10.5 per cent per annum, the equated annual installment during the year 1978–79 (reference year) would turn out to be about Rs.25 per acre. Obviously, repayment of this amount would be cost to the farmers.

Inclusion of this amount into the farmers' cost would adversely affect the private profitability. Values of annual benefit-cost ratios would work out to be 2.95, 2.84, 2.74, and 1.23 for farm-size group I, II, III, and IV respectively. This ratio for all the groups taken together would be equal to 2.47. Thus, values of annual benefit-cost ratios would be reduced if cost of development of OFD works is included in the farmers' cost. However, even under this situation investment in the project remains profitable to the farmers.

To conclude, it is clear from the above analysis that investment in Gandak Canal Project is highly profitable to the farmers in each size group as well as to all the farmers taken together. This means that the government could absorb a part of the additional private benefits to pay for the public cost of the investment. An appropriate means for doing so could be a betterment levy devised in such a way that income disparity among different farmer groups is simultaneously reduced.

F. *Commercial Profitability of the Project from the Public Standpoint: Estimation of Costs and Benefits*

It is now necessary to examine whether the investment in the Gandak project qualifies from the government standpoint as commercially profitable at market prices. For this purpose the project costs include public costs of investment, and operation and maintenance—both of the irrigation project and the command area development project. The time streams of relevant costs are given in Table VII. Since it is an inter-state project involving Uttar Pradesh, Bihar, and Nepal, some works completed under the project are common works. These works include (i) barrage and appurtenant works (excluding head regulator); (ii) head regulator and the Main Western Gandak Canal up to 21.71 km; (iii) river training works in Nepal; (iv) the Main Western Gandak Canal from 21.71 km to 118.08 km being the last off-take point for irrigation channels in Uttar Pradesh; (v) river training works in Uttar Pradesh; and (vi) the Main Western Gandak Canal from 118.09 km to 131.35 km in Uttar Pradesh. In the present study we are considering only those project components which are relevant to Uttar Pradesh. As to the sharing of common costs, no final decision has been reached among the beneficiary states.

TABLE VII

TIME STREAM OF COSTS AND BENEFITS OF THE PROJECT

(Rs. million)

Year	Irrigation Project		CAD[a] Project		Total Cost	Additional Benefits
	Capital Cost	Operational Cost	Capital Cost	Operational Cost		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1960–61	0.2	—	—	—	0.2	—
1961–62	1.6	—	—	—	1.6	—
1962–63	9.2	—	—	—	9.2	—
1963–64	8.1	—	—	—	8.1	—
1964–65	19.3	—	—	—	19.3	—
1965–66	20.6	—	—	—	20.6	—
1966–67	35.0	—	—	—	35.0	—
1967–68	41.3	—	—	—	41.3	—
1968–69	47.6	—	—	—	47.6	—
1969–70	58.8	—	—	—	58.8	—
1970–71	8.6	—	—	—	8.6	—
1971–72	1.2	—	—	—	1.2	—
1972–73	37.8	1.5	—	—	39.3	23.2
1973–74	21.8	2.2	5.7	—	112.7[b]	39.6
1974–75	28.6	3.0	5.6	—	37.2	65.0
1975–76	19.3	4.6	10.3	—	34.8	71.8
1976–77	40.2	4.8	19.7	—	64.9	75.3
1977–78	46.1	5.6	19.6	—	71.3	73.6
1978–79	73.3	6.4	30.3	—	110.0	67.6
1979–80	74.3	7.2	75.0	—	156.6	103.6
1980–81	74.9	8.3	39.1	—	122.3	107.9
1981–82	60.9	8.3	48.6	—	117.8	117.5
1982–83	—	8.3	85.4	—	93.7	127.0
1983–84	—	8.3	91.3	—	99.6	137.2
1984–85	—	8.3	106.8	3.6	118.7	137.2
1985–86	—	8.3	—	—	11.9	137.2
⋮		⋮			⋮	⋮
2001–2002	—	8.3	—	3.6	11.9	137.2

[a] Command Area Development.

[b] Includes Rs.83 million as the cost of common works.

Some tentative estimates of cost to be met by Uttar Pradesh are given in the project report, *Revised Western Gandak Canal Project* (1978) [7]. According to these estimates, the total expenditure on common works for the Uttar Pradesh portion of the project comes to Rs.83.0 million up to the year 1973–74. These are, therefore, included in the total cost figures given in column (6) of Table VII.

In the preceding private benefit-cost analysis, I estimated the additional income benefits for each group of farmers using sample farmers only.

In the present analysis the additional income benefits relate to the whole project area and over the life of the project. To estimate this for any year of the project's life, the total area irrigated in that year and the additional income benefits per

TABLE VIII

YEARLY IRRIGATED AREA, THE MAIN WESTERN GANDAK CANAL PROJECT

(1,000 acres)

Year (1)	Actual Irrigation Potential at the Beginning of the Year (2)	Actual Gross Irrigated Area (3)
1972–73	172	153
1973–74	247	214
1974–75	367	301
1975–76	496	458
1976–77	558	478
1977–78	627	470
1978–79	652	404
1979–80	682	619
1980–81	731	645
1981–82	781	702
1982–83	821	759
1983–84	821	821
⋮	⋮	⋮
2001–2002	821	821

Note: The figures in column (3) of the table are the actual figures up to 1979–80. The rest of the figures for the area irrigated have been obtained by fitting a linear trend ($Y=a+bX$) to the data on irrigated area up to the year 1979–80. The estimated equation turned out to be $Y=1.33+0.57X$. Using this equation it is found that the ultimate irrigation potential likely to be created by the year 1982–83 would be utilized by the year 1983–84. As per the *Draft Annual Plan, 1987–88* [11], Utter Pradesh irrigation potential created and utilized up to 1984–85 stood at 710,000 and 692,000 acres respectively. Thus irrigation potential actually created and utilized up to 1984–85 was much below the expected level as taken in this paper. Commercial profitability is based on the utilization figures as given in the above table, first because data on actual utilization of irrigation potential for all the years after 1979–80 were not readily available. Secondly, updating of this data would call for corresponding change in the basic parameters of profitability, viz., cropping pattern, yield, investment and other costs, etc., which was not possible at this stage.

acre at the aggregate level of the sample farmers have been used. The latter is given in Table I, column (7). It is Rs.167.3 per acre. It should be noted that the definition of benefits and method of their estimation remain the same as mentioned in Section C. The project started providing irrigation facilities from December 1972. Thus, the benefits start accruing from 1972–73 onwards. The total additional benefits due to the project are given in Table VII. According to the project report (1978) [7], the growth of irrigation potential would be such that the entire irrigation potential would have been realized by the year 1982–83. As regards the actual irrigation potential utilized, I obtained the annual figures up to 1979–80 from the project authorities. By that year, 75 per cent of the ultimate irrigation potential had been utilized. In order to project the actual irrigation potential likely to be utilized after 1979–80 and to calculate by which year 100

per cent of the irrigation potential of 821,000 acres would be utilized, I have used a linear trend formula of $Y = a + bX$, where Y is the actual irrigation potential utilized X is the number of years. Yearly irrigated area estimated this way, both actual and potential, are presented in Table VIII.

To estimate the total additional income benefits accruing from the project, I have used the actual figures of gross area irrigated up to 1979–80 and projected estimates thereafter. Since the project was opened for irrigation in December 1972, and as it is estimated to provide irrigation for thirty years, the total life of the project works out to forty-two years. Since project costs given in Table VII and as obtained from project offices are at current prices, consistency requires that benefit estimates also be at current prices. The estimates of income benefits per acre used for the purpose are based on the farm business data relating to the survey year 1978–79. Conversion of benefits at current prices accruing before 1978–79 has been done by adjusting (1) the value of agricultural output by the index number of agricultural production in Uttar Pradesh, (2) the cost of labor at the farm level by the index number of agricultural labor for Varanasi district in Uttar Pradesh, and (3) the rest of the cost of cultivation by the index number of agricultural inputs for all India level. The benefits accruing after 1978–79 have been evaluated using 1978–79 prices. Thus, it is assumed that prices, cropping pattern, and crop yields remain the same after 1978–79 until the terminal year in the project's life. It implies that total income benefits would increase/decrease with the variation in the gross irrigated area over the years. Once the ultimate irrigation potential is completely utilized, (by the year 1983–84 as estimated) total income benefits would remain constant every year till the terminal year of the project's life. The estimated time stream of income benefits from the project is presented in Table VII.

G. *Commercial Profitability*

The benefit-cost ratio, the net present value, and internal rate of return of the project from the commercial standpoint are given in Table IX. For discounting purposes, the year 1960–61, the year when work on the project was started has been taken to be the base year. It may be noted that for the assessment of commercial profitability, the relevant rate of interest at which the investment fund is borrowed is used for discounting the future benefits and costs. Therefore, in order for the project to be commercially profitable, the benefit-cost ratio is required to be greater than or equal to unity and the net present value to be positive at this rate of interest. Moreover, the internal rate of return of the project ought to be equal to or greater than this rate of interest. Now, let us see how far the Gandak project satisfies the test of commercial profitability. Supposing that the investment funds for the project were to be obtained through borrowings from the World Bank. The World Bank has been charging a fixed interest rate of 11.6 per cent which remained unchanged until recently for twenty-year loans. The World Bank's latest interest rate policy is that new loans will bear an interest rate of 11.43 per cent plus 0.5 per cent commission. Obviously, if the funds for the project were to be borrowed from the World Bank, the relevant rate of interest

TABLE IX

ESTIMATES OF BENEFIT-COST RATIO, NET PRESENT VALUE, AND INTERNAL RATE OF RETURN OF THE PROJECT

Rate of Discount (%)	Net Present Value (Rs. million)	Benefit-Cost Ratio
0	1,855	2.14
1	1,277	1.95
2	870	1.77
3	582	1.61
4	380	1.47
5	236	1.34
6	135	1.23
7	63	1.12
8	13	1.03
9	−21	0.95
10	−45	0.87
11	−61	0.80
12	−71	0.74
13	−78	0.68
14	−81	0.63
15	−83	0.58
16	−83	0.54
17	−82	0.50
18	−80	0.46
19	−78	0.43
20	−75	0.39
Internal rate of return=8.39		

would be between 11 and 12 per cent. In India also the scheduled commercial banks are charging on term loans for agriculture a rate of interest ranging from 10 to 12 per cent. This rate of interest is determined by the Reserve Bank of India. Thus, loans taken from banks in India also would bear a minimum interest rate of 10 to 12 per cent.

It is clear from Table IX that at this rate of interest (the relevant rate of discount), the net present value of the project is negative and the benefit-cost ratio is less than unity. As would be expected, the internal rate of return of 8.39 per cent of the project is less than this rate of interest. The conclusion is that from the commercial standpoint, the investment in the project remains unprofitable at any rate of interest greater than 8 per cent per annum.

It is also necessary to examine whether the commercial profitability of the project satisfies the investment criterion suggested by the Second Irrigation Commission (1972) [2, p. 256] and now in use for pre-sanction appraisal of major irrigation projects in India. The commission has recommended that in order for any irrigation project to be acceptable from an economic standpoint, it should have a benefit-cost ratio greater than 1.5. However, the benefit-cost ratio suggested by the commission is not the discounted benefit-cost ratio. It is the annual benefit-cost ratio calculated at the full operation of the project and contains in

the numerator net annual benefits defined as the net value of agricultural produce before and after irrigation, while annual costs in the denominator are comprised of interest on capital costs at the rate of 10 per cent per annum, depreciation, and administrative expenses. Obviously, the commercial evaluation of the project in this study differs from the commission's method in several respects. For example, the approach of evaluating benefits in this study is "with the project" and "without the project," whereas in the commission's method it is, "before the project" and "after the project." Further, the components of costs and benefits are different and while I have used the discounted benefit-cost ratio as the criterion of choice, the commission recommends annual benefit-cost ratio. Therefore, leaving aside the limitations of the irrigation commission's method, the results of my commercial evaluation are not comparable with the former.[6]

H. *Summary and Conclusions*

For the private farmers, the Western Gandak Canal Project has the high benefit-cost ratio of 3.92. As a result of the project, local farmers as a group derive Rs.3.92 worth of income benefits for each rupee they spent on irrigation. The ratio is highest (4.79) for marginal farmers and lowest (1.96) for large farmers. Clearly, the marginal farmers make the best use of irrigation.

The farmers, apparently, do not bear the investment and operational cost of the project, and the cost of irrigation water to the farmers is just the irrigation charges paid. The policy implication of these results is clear. The government could absorb a part of the additional private income benefits to pay for the public cost of investment in the project through appropriate measures like a betterment levy, increasing water rates, etc.

The commercial benefits and costs over the expected economic life (forty-two years) of the project are assessed at the market prices of relevant inputs and outputs. The results of the commercial evaluation show that at 10 per cent rate of interest, which is the minimum interest rate currently charged by the financial institutions in India on term loans, the commercial profitability of the project turns out to be negative with a net present value of Rs.43 million. As would be expected, the benefit-cost ratio is less than unity and the internal rate of return 8.39 per cent which is less than the stipulated rate of interest.

[6] According to the *Draft Annual Plan, 1984–85* [9], the re-revised project is under finalization and the final cost of the project is estimated to be Rs.1,034.5 million. The project was expected to be completed by the end of the Seventh Five Year Plan. Due to the non-availability of detailed data on annual actual cost incurred under the project, it has not been possible to recast the estimates of the internal rate of return (IRR) of the project. However, given the fact that the final cost of the project is higher than the project cost taken in the present study, and the fact that actual utilization irrigation potential is lower than the irrigation potential utilization estimates taken in the present study, makes it sufficiently evident that the commercial profitability expressed in terms of value of IRR of the project would not be higher than the value of IRR of 8.39 per cent worked out in this study. In fact, this implies that any project cost higher than used in this study would adversely affect the values of the decision criteria of commercial profitability and establish the veracity of my estimate of IRR being lower than 10 per cent, the net present value being negative and the value of benefit-cost ratio being less than one.

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APPENDIX

The Sample Survey

The command area of the project has been classified into four major soil groups.[a] As one might expect, the crop yield and cropping pattern in each soil complex is different. With this in mind, four villages, one typical village of average size from each soil group, were purposively selected. The selected villages were: Parsa Buzurg and Gopalpur (in Gorakhpur district), Chakhanipuram Chahapara and Purnaha Mishir (in Deoria district). A comprehensive census of the selected villages was conducted during January–March 1980 while the data collected was related to the agricultural year 1978–79 (July 1978–June 1979). The distribution of sample households by village and by the size of holdings (group I–IV) is given in Appendix Table I.

The total cultivated area classified according to the farm-size groups and divided into irrigated and unirrigated areas is given in Appendix Table II.

In selecting typical villages and taking a census of all the households, it was assumed that information collected this way would be representative of the region in the same way that a stratified sample of farmers randomly selected and scattered over the whole command area would be. In the Gangetic plains, the eco-

[a] Soils in group I consist of very deep fine sandy loam to silty loam in soils, with silty clay-loam, silty-clay, and clay subsoils. Soils in group II consist of very deep silty loam with silty clay-loam to silty clay subsoils. Soils in group III are very deep fine sandy loam to silty loam with fine sandy subsoils. In group IV are very deep sandy alluvium of stratified sediments with amorphous calcium carbonate.

APPENDIX TABLE I

DISTRIBUTION OF SAMPLE HOUSEHOLDS VILLAGE AND GROUP SIZE

Farm-size Group	Gorakhpur District		Deoria District		Total
	Parsa Buzurg	Gopalpur	Chakhanipuram Chahapara	Purnaha Mishir	
I	72	130	55	68	325
II	8	20	19	20	67
III	7	5	5	21	38
IV	12	3	3	2	20
Total	99	158	82	111	450

Note: For farm-size group I–IV, see note to Table I.

APPENDIX TABLE II

TOTAL CULTIVATED AREA IRRIGATED AND UNIRRIGATED OF THE SAMPLE FARMERS

(Acres)

Particulars	Farm-size Groups				For All Members
	I	II	III	IV	
Total cultivated area	741	452	426	547	2,166
Total irrigated area	564 (276)	354 (228)	323 (175)	341 (211)	1,582 (890)
Total unirrigated area	177	98	103	206	584

Notes: 1. Figures in parentheses indicate total area irrigated by canals.
2. For farm-size group I–IV, see note to Table I.

nomic structure of an average village is generally found to repeat itself in other villages of the region. Secondly, this study was a Robinson Crusoe type of enterprise, and trying to cover 450 households scattered over the whole command area would have been simply impossible given the time and resources available. It is for these seasons that the above approach was adopted.

The unirrigated area, taken as control, was not separately selected. It was the unirrigated cultivated area of the sample farmers and, therefore, has similar agro-climatic and natural endowments.