CHAPTER - II

BENEFIT COST ANALYSIS OF IRRIGATION

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Literature on the economics of irrigation has grown very fast since the fifties of the present century, but the difficulties of comparison of the benefits of different irrigation projects and different forms of irrigation have also increased with the growth of literature. The problem of comparison have arisen mainly due to (a) the wide variation in the concepts of costs and benefits used by various authors, (b) regional differences on account of soil, climate and other geo-physical factors, (c) suitability (or otherwise) of different forms of irrigation for particular crops and (d) the differences in the degree of development of related associated factors in other fields at different periods of time. For these reasons,

1. Sridhar Misra found an interesting result while comparing the inter source variation of net benefit of different crops. The net benefit per acre of potato cultivation was Rs.8.82 when the crop was irrigated from mixed minor source and Rs.207.53 when it was irrigated from canal in Meerut district, while in Faizabad district the net benefit increased from Rs.190.46 under canal irrigation to Rs.520.15 when potato was irrigated from mixed minor sources. See Sridhar Misra: A Comparative Study of the Economics of Minor Source of Irrigation in Uttar Pradesh, Report - Oxford and IBH Publishing Co., 1968 p.222
in this chapter we will concentrate mainly on the studies made to find out the benefits of different forms of irrigation rather than compare the efficiency of one form with that of another.

Studies conducted in fifties and sixties mostly analysed the suitability of an irrigation project on the basis of the benefit cost ratio determined by the annuity approach. The approach envisaged the calculation of benefit as the difference in the net additional agricultural output before and after the irrigation and the costs as the sum total of administrative expenses, interest on capital cost of the project at a particular rate\(^2\) and depreciation. The benefit cost ratio of 1.5 was taken to be the break-even point for acceptance of the project.\(^3\)

Sovani and Rath, instead, made a very thorough analysis of both direct and indirect benefits and costs for the Hirakud Project under alternative assumption regarding the interest charges i.e. at 3.75 percent and 10 percent and found the preliminary benefit cost ratio to

\(\text{2. This rate varied from time to time and from project to project.}\)

\(\text{3. There were a few exceptions, K.N.Raj in his study of Bhakra Nangal Project made a detailed analysis of the Project design, man power utilisation, irrigation and output. But the study did not estimate the benefit cost ratio nor the net benefit from the project to the region and the society at large. See K.N.Raji: Some Economic Aspects of the Bhakra Nangal Project, Delhi. 1960.}\)
be 2.4 and 1.58 respectively. Inclusion of secondary benefits and costs improved the respective benefit cost ratios to 2.26 and 1.70. In their calculation of benefits and costs, the annuity approach was followed in which the annual costs were the depreciation, interest charges on total investment, maintenance and associated costs of cultivation and the gross value of increased crop production was the direct benefit, the respective indirect benefits and costs being the value of sugar production and the costs of sugar production calculated on the basis of 80 percent of the total gross production.

In 1958 at the instance of the Research Programme Committee on Evaluation of the Benefits of Irrigation Projects headed by Prof. D.R. Gadgil, studies were taken to evaluate the performances of five major irrigation projects in India. Singh and Misra, while calculating the economic benefit cost ratio of Sarda canal, found some interesting results. It was observed that there was no inter size group variation in net output per acre in the project area.


(net output per acre was Rs.114.00 in case of each group) whereas the variations in net output were wide and significant as between small, medium and big farmers in control area (i.e. Rs.112.00, 98.00 and 40.00 respectively\(^6\)). The annuity approach with an interest charge of 4.5 per cent yielded a direct benefit cost ratio equal to 2.67\(^7\). Calculation of interest at 10 per cent would have reduced the benefit cost ratio to 2.24\(^8\).

K.S. Sonachalam\(^8\), while studying the economics of Cauvery-Mettur Irrigation Project followed the principle evolved by the United Nations Authorities at the Asian Training Centre in 1950. The principle involved calculation of benefits and costs on annuity basis. The benefit cost ratio was equal to 1.77\(^9\).

Jha in his exhaustive study of the Tribeni canal system found that the additional input per acre in project area (this is equal to cost C as defined in different Farm Management Studies of the Government of India) over the control area was about Rs.80.00\(^10\). Total farm receipts per

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6. Ibid. p.90.
7. Ibid. p.130.
8. * This is our calculation.
10. Ibid. p.107.

acre in the project area was Rs.369.00 higher than the receipt per acre in the control area. The net additional benefit per acre, therefore, was Rs.289.00. The total benefit of irrigation was calculated as the additional agricultural output minus the additional agricultural cost. To this was added the net receipt of Irrigation Department from the Tribeni canal. This was the direct benefit. In the social income he included land revenue, water tax paid to the Government, net rent paid to the landlord and hired and family labour income.

So far as the indirect benefits were concerned, he felt that though it should have been taken into account, but because of the unquantifiable nature, it was not possible to measure it. He found the employment of agricultural workers to have increased by 30 days per worker in the project area. Aspects like household industrial activity, rural transport and urban development both in the project and control areas were analysed to mark the differences.

In a study of the Hirakud Project, the Bureau of Statistics and Economics estimated the net income from

12. Ibid p.252.
Irrigation, calculated on "with and without" principle, equal to Rs.37.00 per acre at 1964-65 prices. The study did not make any attempt to find out the net benefits of irrigation as the cost calculation included only irrigation charges paid and not the cost of irrigation. The inter crop variation in net profit was found to be very wide. The cultivation of sugar cane yielded the maximum net income of Rs.668.00 per acre whereas the cultivation of autumn paddy, groundnut and moong led to loss.

By using the data from the studies made in India in fifties and sixties Colin Clark found the gross and net marginal product of irrigation, without taking into account the costs of hired labour and farm labour, varying between 0.42 to 1.63 tonnes of wheat equivalent per hectare and 0.03 to 2.26 of wheat equivalent per hectare respectively. After debiting the hired labour cost and the total cost of labour the net marginal product varied between 0.02 to 2.16 and 0.02 to 2.19 tonnes of wheat equivalent per hectare respectively.

The Irrigation Commission recommended the same annuity approach followed earlier with only one change i.e., use of 10 percent rate of interest on capital in preference to lower interest rates. It also felt that the benefit cost ratio of greater than 1.5 should be considered acceptable from the economic point of view. It apprehended that a lower benefit cost ratio would lead to the acceptance of marginal projects which might prove uneconomic because of rise in construction costs in future. However, the Commission felt that "thesis rule should not be rigidly applied in drought affected areas ... A lower limit of one for the benefit cost ratio may be accepted for such projects even if it later proves to be somewhat uneconomical."

There are several shortcomings in this approach. It does not take into consideration the time factor, trends of cost and output streams in the life of a project. It also fails to reflect the preference of the present consumption over the future consumption which is an observed phenomenon. The assumption of a normal output stream does not allow for the risk and uncertainty that are involved in future life of a project. It also fails to take into account the

18. It has recommended for a higher rate of interest i.e. 10 percent to cover the risk and uncertainty. However, the risk and uncertainty for various projects differ widely and the use of a high rate of interest cannot take full care of them.
sensitiveness of the project benefit to the changes in the discount rates (or interest rates), relative prices of inputs and outputs, divergences between market and social price of inputs of outputs, the factors which are very important from the economic point of view. Use of social prices might change the ordering of projects obtained through the benefit cost ratio on annuity approach. The criterion also is inadequate to take into consideration the opportunity cost of the scarce or abundant resources of the economy. Neglect of the income distribution aspect, both inter and intra regional, appears to have made the criterion, for a country like India, having wide disparities in inter regional and inter personal incomes, not very suitable for project choice.¹⁹

While comparing the benefit cost ratio with the 'Rate of Return Method', the Commission preferred the former and thought that the latter would be more appropriate "as a basis for making a choice between two investments and where financial return is the dominant consideration and no constraints are imposed by national goals"²⁰ Since India is a capital scarce country it would be desirable to use it in most judicious manner and, therefore, the ranking of


²⁰. Irrigation Commission op. cit. p. 252.
project on internal rate of return would be very much appropriate even in regions having special difficulties like drought prone area and backward regions. But the use of benefit-cost ratio for selection of projects may lead to a bias in favour of projects in the advanced states having better advantages than their less fortunate counterparts.

Recently the World Bank Team\(^2\) evaluated three projects in India, Purna Power Generation and Irrigation Project in Maharastra, Shetrunji Irrigation Project in Gujurat and Salandhi Irrigation Project in Orissa and calculated the benefit and costs on the basis of 'with and without' principle. The rates of return calculated by them were 11.2 percent, 17.4 percent and 17.3 percent respectively.

At the instance of the Planning Commission, the P.E.O. undertook\(^2\) a study on the benefit cost aspects of major irrigation projects in India to find out the economic benefit cost ratios at different rates of discount. It also attempted graduated discount rates, 5 percent for first 5 years, 7 percent for next 10 years and 10 percent for next 10 years, to mark the variations in the

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## BENEFIT COST RATIOS AT DIFFERENT RATES OF DISCOUNT

<table>
<thead>
<tr>
<th>Project</th>
<th>5%</th>
<th>7%</th>
<th>10%</th>
<th>5% for the first 5 years</th>
<th>7% for the next 10 years</th>
<th>10% for the next 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kakrapar</td>
<td>1.50</td>
<td>1.25</td>
<td>0.92</td>
<td>1.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tungabhadra</td>
<td>2.93</td>
<td>2.41</td>
<td>1.81</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hirakud</td>
<td>1.83</td>
<td>1.58</td>
<td>1.23</td>
<td>1.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gangapur</td>
<td>6.60</td>
<td>5.48</td>
<td>4.18</td>
<td>5.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malampujha</td>
<td>2.58</td>
<td>2.05</td>
<td>1.90</td>
<td>2.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Bhawani</td>
<td>4.07</td>
<td>3.37</td>
<td>2.56</td>
<td>3.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matatila</td>
<td>1.82</td>
<td>1.57</td>
<td>1.22</td>
<td>1.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mayurakahi</td>
<td>3.62</td>
<td>2.66</td>
<td>2.01</td>
<td>2.72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: PBO op.cit, (mimeo) Table 2.3, p.23.
benefit cost ratios of different projects. The following table presents the data from the P.E.O study.

However, they admitted the difficulties of comparing the benefit cost ratios because of the limitations of data. Since this analysis rested on the data for only 25 years and not the entire lift of the project, it cannot be called a complete analysis. Further, the study did not take into account the elements of risk and uncertainties because of the non-availability of data.

Choptrra made a thorough social benefit cost analysis of the Bhakra Nangal Project with alternative assumptions regarding the shadow price of labour, shadow price for foreign exchange, social rate of discount and shadow price of investment with cost estimates having lower and upper limits. She tried to find out the sensitiveness of the net present value of benefits to the changes in the value parameters. Both the regional effects and the aggregative effect of the investment were studied. With different combinations of the assumptions 126 alternative values of the regional effect and 189 alternative values of the aggregative effects were found. The range of regional benefits varied from rupees 2508 millions to rupees 281 millions. The aggregative effect had negative values.

23. PEO, op. cit. p. 25.
It was found that the regional income had grown much more than the aggregative income.

Sinha and Bhatia\textsuperscript{27} in a recent study of Auranga project have made a thorough analysis about the benefit cost ratios, net present values and the internal rates of return at alternative assumptions about the cost structure, delay in constructions, fluctuations in the yield at alternative rates of discount. It was observed that the benefit cost ratios, net present values and internal rates of return were substantially higher when the project was evaluated at social prices than at market prices. The benefit cost ratios at market prices varied between 0.52 to 1.45 whereas these ratios at social prices varied between 1.85 to 4.19. It was also found that among technical alternatives, earth dam was costlier than the masonry dam at social costs whereas it was just the opposite in the case of the cost calculation at market prices\textsuperscript{28}. They further found that the benefits of irrigation can be maximised by spreading irrigation more extensively than by using intensive irrigation. Their technical alternatives of the cropping pattern with different intensities of irrigation are a valuable contribution to the economic analysis.

\textsuperscript{27} Sinha and Bhatia op.cit.
\textsuperscript{28} Sinha and Bhatia op.cit.
Micro studies in economics of minor irrigation, with a few exceptions, in sixties and seventies mostly followed the annuity approach in one form or another. Maji and Sirohi, following the conventional benefit cost technique evaluated a deep tubewell project with two alternative prices of electricity per unit, with 8 hour and 16 hour a day operation and with three discount rates 6.5, 7.5 and 10 percent. Their results showed that the benefit cost ratio varied between 2.12 to 3.74 under different alternative assumptions.

In another study Moorti and Mellor found the private tubewells to be more efficient than the state tubewells in Uttar Pradesh. The gross returns per hectare on the state tubewell farms were Rs.910.00 as against Rs.1700.00 per hectare on farms irrigated by private tubewells. It was also observed that the returns for direct costs on water was twice as high on farms with private tubewells as for those with state tubewells. The marginal value product to cost of water varied between 1:2 to 1:4 for state and private tubewells respectively. They also observed

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that the cost of $1000 \text{ m}^3$ of water in case of private tubewells to be about 67 percent of the costs for the same volume of water under Government tubewells.

Patel in his study\textsuperscript{32} found the operating cost of 1 acre inch of water under disselised pumps to be Rs.9.60 whereas in the use of electric pump sets the cost for equal volume of water was Rs.5.87.\textsuperscript{33} Further, the higher lubrication costs, higher labour cost and bigger share of the fixed cost in case of the diesel pumps than the electric pumps increased the cost per unit of water substantially higher than the cost of water under electrified pump system.\textsuperscript{34} He felt, the farms could gain substantially by switching over from dieselised pumps to electrified pumps.

Chauhan and Agarwal\textsuperscript{35} worked out the cost of irrigation per acre of wheat crop from an average depth by Charsa, Persean wheel, pumpset, diesel and electric motor in Jeypore district of Rajsthan. They found the cost


\textsuperscript{33} S.M. Patel op.cit p.180.

\textsuperscript{34} Ibid pp. 180-181.

of Irrigation by electric motor equal to Rs.8.44 per acre which was about one-sixth of Charsa, one-fifth of Persean wheel and half of the diesel engine.

Shridhar Misra in a very interesting study showed that the minor sources of irrigation provided more output per unit of area than the canal system. The net output for all minor sources combined was higher than that of the canal system by 1.35 percent in Meerut and 10.140 percent in faisabad. The inter source variation of output of particular crops varied very widely as between regions.

A study from Bangla Desh revealed that the irrigation through shallow tubewells was more labour absorbing per unit of area than from tubewell. It was found that the labour requirement per acre increased from 998 to 1360 labour hours from unirrigated and deep tubewell farms to 1850 labour hours for the shallow tubewell irrigated farms. Shallow tubewells also led to maximum return per acre.

39. Ibid, p.46.
40. Ibid, p.49.
Mukhopadhayay, by using the data from the study of Chowdhury\(^1\) made an analysis of alternative tubewell irrigation projects in Nadia\(^2\). He found the benefit cost ratio in case of deep tubewells is higher (2.75) than shallow tubewells (1.87). But the Internal Rate of Return in case of shallow tubewells was 50 percent which was much higher than that of the deep tubewells (34 percent). From this he concluded that the shallow tubewells have a distinct preference over the deep tubewells.

Dhawan made an exhaustive study of the significance of the modern and traditional techniques of ground water exploitation\(^3\) and refuted the arguments that the private tubewells were more efficient than the public tubewells. He showed that from the long run social point of view it would be economical for the ground water exploitation to be handled by the State Government. This would also help in overcoming the problem of inadequate utilisation of ground water due to size disability.


The studies on Minor Irrigation in Orissa usually followed the criterion of conventional annuity benefit cost ratio for the evaluation of minor irrigation projects. A study of minor irrigation projects conducted by the State Evaluation Organisation found that the net return per acre on average increased by Rs.62.65. The interproject variation of net return per acre, however, was very wide, varying between 3.06 to 154.84. The benefit cost ratios at 5 percent and 10 percent rates of interest were 1.20 and 0.82 respectively. Out of 16 projects only 5 projects and 2 projects respectively qualified according to the basis of 5 percent and 10 percent rates of interest. In another study following the same methodology the State Evaluation Organisation found that the benefit cost ratios were 3.61 and 3.01 at 5 percent and 10 percent rates of interest respectively. Only 12 out of 17 Lift Irrigation Projects passed the test of acceptance.


45. Ibid p.29.

46. Ibid p.39.

The Bureau of Statistics and Economics strictly followed the guidelines of the Irrigation Commission and found that out of 10 lift irrigation projects in coastal Orissa, 5 were having benefit cost ratio above 1.5 and out of 4 reservoir projects, 3 were on the higher side of 1.5 benefit cost ratio.

In a study on the economics of irrigation in Nayagarh Sub-Division of Orissa, Das found that the expenditures on cultivation per acre in irrigated and unirrigated areas were Rs. 2002.91 and Rs. 490.54 respectively. The net profits per acre in respective areas were found to be Rs. 1637.88 and Rs. 261.68. It was also observed that the net income per acre was substantially higher in respect of big farmers than in case of small farmers.

In another study, he found that the intensity of cropping increases from 186.42 for unirrigated farms to 269.02 in case of tubewell irrigated farms. The irrigated farms changed their cropping pattern substantially in favour of cash crops in Rabi whereas the unirrigated farms...

50. Ibid p.45.
52. Ibid p.64.
depended mostly on the low valued food crops. About 30 percent of the gross cropped area of the irrigated land was put to summer crop whereas nothing was grown during summer on the unirrigated lands. Under two alternative assumptions of 20 acres ayacut and 30 acres ayacut, the benefit cost ratios were 1.84 and 1.90 respectively. Though the annuity approach was followed by him, his approach differed from the conventional approach in respect of the calculation of costs and benefits. Unlike the earlier studies, he included the additional cost of cultivation under the cost heads and the benefits represented the difference in gross benefits between the irrigated and unirrigated lands.

Tripathy and Champati followed a different methodology to estimate the benefit cost ratio of the Lift Irrigation Projects in Orissa. Instead of taking the investment cost they took the interest charged on investment cost and discounted them at 10 percent and added the discounted maintenance cost to it to find out the cost of the Project. The discounted value of additional benefits constituted their benefits. In this also a cost element (i.e. the additional cost of cultivation) was deducted from additional

53. Das, op. cit., p. 73.

gross benefits. By following this methodology they have under estimated the costs as well as the benefits. However, the under-estimation of costs seems to be at a higher rate than the under-estimation of benefits thereby inflating the benefit cost ratio. The benefit cost ratios varied between 0.44 and 12.82.  

Studies on well irrigation in India are only a few in number. Deepak Lal in his analytical study of social benefits of small scale irrigation made a detailed study of the costs and returns of open wells in Ahmednagar Taluka of Maharastra. The social rates of return varied between 2.5 to 24.0 for jowar under alternative assumptions about shadow wage rate, prices of jowar and the cropping intensity. Rates of return of sugarcane varied between (-)46.70 to 87.76 on different alternative assumptions about the prices of sugarcane and the shadow wage rate. He followed the Little Mirrlees method for valuation of inputs and outputs.

Shukla found well irrigation resulting in higher income both for traditional and advanced farms. The difference in programmed incomes of the traditional unirrigated and irrigated farms was Rs. 30.10 per acre. The difference between the advanced irrigated and unirrigated farms was Rs. 202.43 per acre.

55. Ibid op.cit p.83.
57. Deepak Lal, op.cit, p.141.
From the above review, it is observed that the results obtained in different studies are not comparable because of the wide variations in the concepts of benefits and costs. The only study on benefit cost analysis of wells made by Ial had tried to find out the returns from the point of view of two crops with alternative assumptions of cropping intensity and price. In our study, we will mainly concentrate on the admissibility of the project by taking into account the existing cropping pattern with alternative shadow wage rates and try to find out the suitability of different sizes of wells according to the specific admissibility criteria.