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Do Dams Help Reduce Poverty[1]

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SUMMARY

The simulation results based on a SAM-based multiplier model show that the Bhakra dam project has generated significant indirect or downstream effects in the Punjab state. The estimated multiplier value is 1.90. Thus for every rupee (100 *paise*) generated directly, another 90 *paise* were generated in the region as downstream or indirect effects. These multipliers include the effects of inter-industry linkages as well as the consumption-induced effects. The multiplier effects will be much higher if indirect and induced effects of remittances sent by agricultural workers from the Punjab and contributions of the Bhakra dam towards 'Food for Work' program were to be included in the analysis. The results on income distribution show that all sections of the society, not only landed households but the poor marginal and small farmers as also landless agricultural labor also gain. In fact the gains to the agricultural labor households from the dam have been higher than the gains to other rural households and to urban households.

Key words: Poverty, Multipliers, SAM, CGE.

1. INTRODUCTION

Concern for increasing agricultural production to either fulfill the rising food grain demand of increasing population and/or to minimize the impact of vagaries of weather on agricultural production has invariably driven public agencies and donors in bringing larger area under irrigation and in investing huge resources for development of small, medium, large - single and multipurpose irrigation structures. For an individual farmer, investing in a private tube well, the main concern is to have a larger control over irrigation water and thereby increase production on his farm. Concern for providing safe drinking water and sanitation facilities for rural and urban population has often guided large public and donor investments in rural and urban water supply and sanitation programmes. Investments in hydropower have consistently been governed by the need for producing energy. Similarly investments in flood control structures have been guided by the concerns for minimizing the impacts of the floods on the property and life of the affected population.

These water development and management concerns have by and large not been viewed as poverty reducing strategies *per se*, though the poverty reducing impacts of these investments, specially that of investments in canal irrigation infrastructure, have often been recognized. Such investments have generally been justified for realizing broad based growth, for increasing agricultural production and achieving food security, for increased hydropower generation, for making drinking water available to rural and urban areas etc. with poverty reducing impacts of these investments being assumed implicit. Given the complexity of the process through which water-poverty interrelationships operate and given the multifaceted dimension of poverty, it has often proven to be difficult to ascertain if the availability of water *per se* has lead to a reduction in poverty. Large amount of literature available on poverty provides no coherent analysis of the relationship between water access and

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use and poverty. As a result the debate on poverty reducing impacts of water has generally been unconvincing and vacillating.

The present paper attempts to provide a somewhat more persuasive answer to the often debated issue: does development and more efficient management of water resources lead to a reduction in poverty? We provide empirical analysis to demonstrate that investments in large water resources development projects, such as multipurpose dams, benefit all sections of the society, including the poor and the landless, thereby serving as a major mechanism for combating poverty.

2. WATER RESOURCES DEVELOPMENT AND SHARING OF ECONOMIC BENEFITS

Investments in large water resources projects providing multiple benefits including irrigation, hydropower, water supply and flood control, generate a vast array of economic impacts both in the region where they are located, and at an inter-regional, national and even global level. These impacts include both 'direct' and 'indirect' or 'multiplier' impacts. In general, ex-post and ex-ante evaluation of these projects include valuation of only direct impacts such as irrigation, hydropower, water supply, fish production, flood control and recreational benefits. In such evaluations, however, indirect or multiplier impacts of such projects are often not taken in to account. Ignoring these indirect impacts result in underestimation of the total impacts of a project on regional and inter-regional economies.

Indirect and induced impacts are those that stem from the linkage between the direct consequences of a dam project with the rest of the economy. Indirect impacts of dams comprise

- inter-industry linkage impacts, both backward and forward linkages, resulting in increase in the demand for outputs of other sectors and
- consumption induced impacts arising out of increases in income and wages generated by the direct outputs of the dam

While the direct impacts of these projects have been well understood and analyzed, the indirect impacts of these water resources projects have often neither been explicitly and fully understood and appreciated nor have generally been quantified. As noted by the Operations Evaluation Department of the World Bank (1996, p 20), "irrigation projects have, in general, substantial benefits stemming from linkages between irrigation and other sectors of production. Thus, the increased income of irrigated farmers will result in increased demand of complementary inputs to production (fertilizers, tractors, fuel), increased scope for downstream processing of the irrigated crops, and increased spending on consumption goods produced locally and outside the region. Unfortunately, there are no estimates available on the indirect benefits of the projects under review". The World Commission on Dams in its final report also concludes that " [...] a simple accounting for the direct benefits provided by large dams – the provision of irrigation water, electricity, municipal and industrial water supply, and flood control – often fails to capture the full set of social benefits associated with these services. It also misses a set of ancillary benefits and indirect economic (or multiplier) benefits of dam projects" (WCD 2000).To that extent thus the quantification of the economic impacts of these projects have been incomplete and therefore inferences drawn about the benefits emanating from these projects and how these benefits have been shared by different sections of the society have been partial, flawed and possibly sometimes prejudiced.

3. ESTIMATION OF MULTIPLIERS: ANALYTICAL TOOLS

As explained above, the direct outputs from a dam generate both inter-industry linkage impacts and consumption-induced impacts on the regional/national economy. The magnitude of indirect impacts of a dam on the regional output and value-added will, however, depend on the strength of linkages amongst various sectors of the economy. Multiplier analysis offers one of the approaches for quantifying the magnitude of inter-industry linkages and consumption-induced effects in relation to purely direct impacts.

Multipliers are summary measures that reflect the total effects of a project in relation to its direct effects. A multiplier of 1.50, for instance, implies that for every one dollar of value-added generated directly by the project at maturity, another 50 cents are generated in the form of indirect or downstream effects. Thus, the multiplier is a ratio of the total effects (direct and indirect) of a dam project to its direct effects. Estimation of multiplier thus requires careful analysis of the direct effects. This essentially involves quantification and valuation of major outputs of the dam and the assessment of the share of direct effects that is attributable to the dam project. As shown in Table 1, for estimating a project multiplier value for a dam, for the numerator, we need to estimate the regional value added under 'With Project' situation as well as the regional value added under 'Without Project' situation. For the denominator, we need to estimate the value added from the sectors that are directly affected by the major outputs of the dam (namely agricultural output and hydro electricity).

Table 1. Values of variables required for the estimation of a project multiplier

Definition of Project Multiplier	Regional Value Added With Project **minus** Regional Value Added Without Project —————————— Value Added of Agriculture and Electricity With Project **minus** Value Added of Agriculture and Electricity Without Project

In the literature, the following economy-wide, multi-sector models have been proposed to estimate indirect and induced impacts and to perform income distributional analysis of dam projects:

- Input-Output (I/O) and Semi-Input Output (S-I/O) Models
- Social Accounting Matrices (SAM)-based Multiplier Models
- Computable General Equilibrium (CGE) Models

The I/O and S-I/O models evaluate indirect and induced economic impacts by computing multipliers embodying the impact of a unitary change in one sector's output – due to an exogenous change in final demand – onto the output of other sectors, income, and employment. Existence of a multiplier depends on drawing unused or underused resources into more productive economic activities, Haggblade *et al.* (1991) so that the presence of such underutilized resources in the region of interest is crucial for the existence of multiplier impacts as estimated by this class of models. Leontief or output multipliers only reflect the degree to which industrial sectors are linked with each other and the strength of such linkages, but tell us nothing about the larger or smaller impact on a regional or national economy of increased demand for the output of any of those sectors. The main limitation of this category of models is that they assume linearity in production and cost-determined prices independent of demand. The results from these models do not include income distribution and poverty reducing impacts of dams.

Another set of linear models – SAM based – extend the input-output table to include the distribution of income among "institutions" (household categories, firms, the government), to better represent their expenditure, and to distinguish between production activities and produced commodities. A Social Accounting Matrix (SAM) is a comprehensive, economy wide data framework that represents the circular flow of income and expenditure in the economy of a nation or region. Most of the limitations characterizing I/O models – their demand driven nature, lack of price responsiveness, linear inter-sectoral interactions and factor use – also affect SAM-based multiplier analyses. However, they represent a step forward in that they close the loop between factor incomes, their distribution to different endogenous and exogenous economic agents, and their expenditure behavior. A crucial distinction between SAM-based multiplier analysis and I/O models is that SAMs are able to account for the way in which initial asset distribution and factor endowments – and therefore the distribution of income among household categories and between them and the corporate sector – interact with the structure of production in determining final outcomes, particularly for welfare analysis.

In a world where policy makers cannot control quantity variables directly – as it is implicitly assumed by linear I/O and SAM-based models – but rather affect them via the mediation of market incentives, one needs to understand how markets respond to different sets of policy interventions. CGE models are well suited to this purpose, providing a framework where endogenous prices and quantities interact to simulate the workings of decentralized markets and autonomous economic decision-makers. Standard CGE models have been extensively used to study policy impacts on income distribution, growth and structural change in developing economies. (Devarajan *et al.* (1986, 1990), Decaluwe and Martens (1988), Bandara (1991)). A CGE model is a system of simultaneous nonlinear equations that provide a complete and consistent picture of the "circular flow" in an economy, capturing all market-based interactions among economic agents. Four features distinguish CGE models from Leontief's input-output modeling tradition:

- Price endogeneity, as opposed to quantity adjustments, to reach an equilibrium
- Price-responsive input and output substitutability – perfect or imperfect – through the use of nonlinear supply and demand equations (Robinson, 1989)
- The abandonment of the perfect dichotomy between traded and non-traded goods from traditional I/O models
- Factor supply constraints, which generate output supply constraints

While each of these three types of models can be used for estimation of indirect and induced effects, SAM-based or CGE models are better suited for the analysis of income distribution impacts of a dam project. From the point of view of the analysis of indirect and induced impacts of dam projects, the choice of analytical tool should not always favor the most sophisticated tool, but rather be driven by the assumptions regarding the mechanisms through which impacts are transmitted in the specific region of interest – particularly factor mobility. When prices are assumed fixed, as in I/O or SAM-based multiplier analysis, all adjustments occur through quantity changes, Bell *et al.* (1982). In the absence of supply constraints, adjustments occur via impacts on labor or capital employment and inter-regional factor migration. The presence of idle labor or capacity in the system – either locally or in other regions, if the model is inter-regional – is thus crucial for the existence of quantity-driven multiplier impacts as estimated by these models.

On the other hand, a variable-price model, such as a standard (Social Accounting Matrix (SAM)) CGE, implies the presence of supply constraints, so that for at least one factor the aggregate levels of factor employment are fixed. In this case, a change in sectoral demand results in relative price changes, determining substitution effects among inputs and among outputs, with factor reallocation across sectors in the regional economy. If available, a CGE could also be used to compute SAM-based, fixed price multipliers analysis, making it possible to highlight the differential impacts that can be seen when considering changes in relative prices, factor mobility and wage differentiation.

4. ESTIMATING INDIRECT ECONOMIC IMPACTS OF DAMS: EMPIRICAL ILLUSTRATION FROM BHAKRA MULTIPURPOSE DAM SYSTEM, INDIA (BHATIA AND MALIK 2004)

The Bhakra-Nangal Project, located in North-West India, is a multipurpose river valley project encompassing the three eastern flowing rivers- Satluj, Beas and Ravi- as well as the Yamuna river. The project is a splendid example of Integrated Water Resources Management

Table 2. Bhakra-Nangal-Beas system : Salient features

	Bhakra Dam	Nangal Dam	Beas Unit I-Pandoh Dam-Dehar Power Plant	Beas Unit II
Type of Dam	Concrete straight gravity		Earth cum Rockfill	Earth Core Gravel Shell
Height above deepest foundation	225.55 metres		76.2 metres	132.59 metres
Height above river bed	167.64 metres	29 metres	61 metres	
Length at top	518.16 metres	304.8 metres	255 metres	
Width at top	9.14 metres		12.19 metres	
Catchment Area of Reservoir	56980 square Kms			12560 square metres
Area of Reservoir	162.48 square Kms			
Live storage capacity	6911 million cum		18.56 million cum	7290 million cum
Gross storage capacity	9340 million cum		41.00 million cum	8570 million cum
Number of Power houses/units	2	2	6	6
Capacity of power plants	1375 MW (5*180+3*157+2*132)	154 MW (4*24+2*29)	990 MW (6*165)	360 MW (6*60)

(IWRM) as the project was planned not only on a basin level but also included inter-basin transfer of water from surplus basins to deficit basins. It is also an excellent example of Inter-State cooperation amongst the states of Punjab, Haryana, Rajasthan and Jammu & Kashmir on sharing of water.

The Bhakra dam, completed in 1963, is a 225.55 metres (740 feet) high straight concrete dam. The lake created by dam is 162.48 square km in area with gross storage of 8340 million cum. The Nangal Dam, situated about 13 kms downstream of Bhakra dam, is 29 metres (95 feet) high and comprises 26 bays of 9.14 metres (30 feet) each. It is designed to pass a flood of 10000 cumecs (350000 cusecs). The dam diverts the water of river Sutlej in to Nangal Hydel Channel and Anandpur Sahib Hydel Channel for power generation and irrigation purposes. Nangal pond acts as a balancing reservoir to smoothen out the diurnal variation in releases from Bhakra Power Plants. The Nangal barrage provides the headwork for the 414 cumecs Nangal hydel channel with hydro stations at two falls at Ganguwal and Kotla with a combined installed capacity of 154 MW. The Bhakra main canal (360 cumecs) takes off from the Ropar headwork 60 kms from Nangal Dam to irrigate large tracts and firm up supplies to some older systems. The Beas Project I comprises of a diversion dam at Pandoh, several hydel channels, tunnels, control works, a balancing reservoir and Dehar power plant while Beas Project unit II comprise of Pong dam, tunnels, spillways and Pong power plant. The salient features of the Bhakra dam system are given in Table 2.

5. THE MAJOR OUTPUTS OF THE BHAKRA DAM

The major outputs of the Bhakra dam, *inter alia*, are:

- Increased availability of water for irrigation resulting in higher agricultural output
- Availability of water for industry, household enterprises and drinking for households and livestock
- Generation of hydro power
- Moderation of floods reducing flood damages significantly

The availability of water from the Bhakra dam system has resulted in a very substantial increase in the availability of irrigated area for cultivation. In 1996-97, net irrigated area in the Bhakra dam system command area of Punjab and Haryana was 5.6 million hectares compared with 3.0 million hectares in 1955-56 (without Bhakra dam). The availability of gross irrigated area during the forty-year period (1996-97 over 1955-56) however increased by about 220 per cent i.e. from 3.2 million hectares to 10.3 million hectares. The increase in the availability of irrigated area has been the combined effect of increase in the availability of surface irrigation from the Bhakra dam and associated groundwater pumping facilitated by increased recharge of groundwater from the canal system and availability of hydropower from the Bhakra dam for pumping this groundwater.

The increase in the availability of irrigated area from the Bhakra system and other sources led to significant increases in foodgrain production in Punjab and Haryana. By 1980, the production of foodgrains in the two states was around 18 million tons or 19 per cent of the total all-India production. As much as 55 per cent of the total increase in foodgrain production in the country over two decades (1980 over 1961) came from the region where Bhakra dam is located. As a result of such high increase in domestic production, the net imports of foodgrains declined substantially from 10.3 million tones in 1966 to almost zero in 1972. The total foodgrain production in the Bhakra command area during the year 1996-97 was of the order of 27 million tones, an additional output of 25.2 million tones compared with the food output in mid 1950s.

The hydro power stations installed in the Bhakra system, having a combined generating capacity of 2880 MW, currently generate about 14000 million Units (kWh) of electricity in a year. It has set up transmission lines running in to 3738 ckt kilometres. The power generated from the system benefits seven states/union territories. Bhakra-Beas Management Board (BBMB) supplies about 50 per cent of the total hydropower in the Northern region besides meeting the peak demand of about 2500 MW of the Northern Grid. The 14110 million units of hydropower generated in 1998-99 evaluated at a conservative price of Rs 2 per unit are worth Rs 28220 million. The operational cost of power generation and transmission work out less than Rs 0.10, perhaps cheapest in the world (Gopalakrishnan 2000).

Table 3. A SAM-based multiplier model of the Punjab regional economy

Expenditures / Receipts	Households (HHs) k=1,..,5	Production Sectors i = 1,2,...39	Capital Account	Government	Rest of the World	Total
Households k = 1,..,5	0	$\sum_i w_{ki} X_i$	0	0	R_k	Y_k
Production Sectors i=1,2,...39	$\sum_k c_{ik} Y_k$	$\sum_j a_{ij} X_j$	J_i	G_i	E_i	X_i
Capital Account	S_k	S_i	0	S_g	S_R	F
Government	$\sum_k t_k Y_k$	$\sum_i t_i X_i$	0	0	R_g	G
Rest of the World	M_k	M_i	0	M_g	0	M
Total	Y_k	X_i	F	G	M	

These changes in availability of additional foodgrains and electricity in the Bhakra system have led to a number of other benefits in the benefited region- 100 per cent rural electrification in Punjab and Haryana, widespread installation of private tube wells, a very significant reduction in poverty, overcoming problems of recurrent floods etc. The project has not only benefited the region where it is located but the benefits have extended to regions far beyond its geographical location. Thousands of labour from distant poor states now migrates each year to Punjab and Haryana in search of employment. It has been estimated that total earnings of the entire migrant labor force in crop production in Punjab during 1995-96 was Rs 5344 million (US$ 114 million) out of which they remitted Rs 3548 million (US$ 75 million or 66 per cent) back to their native places with its attendant multiplier impact in the receiving native villages. The surplus foodgrain produced in the Bhakra regions have been used for a number of "Food for Work" programmes of the government. The water from the system also provides drinking water facilities to a large number of rural and urban areas including the city of Delhi.

These positive on-site and outside region impacts have, however, also been accompanied by a number of other social, environmental and ecological impacts- both positive and negative. As in the case of any large project, construction of Bhakra dam also led to displacement of people, sedimentation of reservoirs, water logging and soil salinity, groundwater pollution, increased emission of methane, larger seismic impacts etc. On the positive note it also helped in making deserts green, in restoration of loss due to forest submergence, in mitigation of green house gas emission etc.

6. MULTIPLIER EFFECTS OF THE BHAKRA DAM SYSTEM IN THE PUNJAB STATE

As discussed above, the Bhakra dam system has benefited not only the directly impacted states of Punjab, Haryana, Rajasthan, Himachal Pradesh and Delhi but also the entire country. For the estimation of multiplier effects of the dam, we will, however, confine to the direct benefits and indirect benefits, operating through both the inter-industry linkage impacts and consumption-induced impacts, of the dam system in only a part of the benefited area viz. the state of Punjab. This is because the input-output model and the Social Accounting Matrix (SAM) required for estimating the multiplier were available only for the state of Punjab and not for the entire Bhakra system encompassing other states.

7. A SAM-BASED MULTIPLIER MODEL OF THE PUNJAB ECONOMY

This study uses an estimated social accounting matrix (SAM) to provide a detailed quantitative description of the Punjab economy in 1979-80, almost twenty years after the construction of the Bhakra dam was completed. The SAM framework provides a consistent, comprehensive, and detailed picture of the transactions in the economy. Production activities, government and households are considered and the pattern in which incomes are distributed takes its place alongside the sources of its generation. The SAM also provides a basis for the construction of a model of the regional economy that is used to estimate the direct and indirect impacts of increased agricultural production and electricity output available from the Bhakra dam. Table 3 shows the interactions among different accounts in the SAM. The model is calibrated for the year 1979-80 for Punjab. In the SAM-based multiplier model there are 39 production sectors including agricultural sectors, manufacturing, electricity, gas and water supply, trade and transport services etc. There are 5 types of households namely, self-employed rural households, rural households employed as agricultural labor rural non-agricultural labor households , other rural households and urban households. The data source for estimating the full SAM is a detailed study of the Punjab economy reported in Bhalla *et al.* (1990).

The notation used stands for the following:

The subscript $k = 1, 2, \ldots, 5$ denotes the type of households, while i, j denote the production sectors.

Y_k = total income of households of type k

X_i = value of gross output of sector i

w_{ki} = coefficient (ratio) of value added received by household type k to output of sector i

R_k = income transfers from abroad to households of type k

c_{ik} = proportion of income household k that is spent on the purchases of sector i's output

a_{ij} = input-output coefficient for production sectors

J_i = investment demand of sector i's output

G_i = government purchases of sector i's output

E_i = exports of sector i's output

G = total tax revenues

t_k = tax rate for households of type k

t_i = tax rate for production sector i

R_g = income received from 'rest of the world' by the government

F = total savings in the regional economy

S_k = total household savings

S_i = savings/ investment by production sectors

S_g = government savings

S_R = exogenous inflow of capital

M = total value of regional imports

M_k = expenditure on imported goods by household of type k

M_i = value of imported intermediates purchased by sector i

M_g = imports by the government

As in a Leontief system, we assume that all the structural relations (both behavioral and technological) are linear or at least that they can be approximated to linear functions.

The model has been used to compute the values of relevant variables in the 'With Project' situation with their counterparts in the hypothetical case that the project had not been undertaken. This set of variables comprises all the elements of a SAM for the region in each situation, assuming fixed prices. In assessing the situation for the hypothetical case of absence of the project it has been assumed that all autonomous changes would have taken place except the effects of changes due to major outputs of the project, namely irrigation and hydro-electricity. This hypothetical case in the absence of the project is termed as 'Without Project' scenario for 1979-80. The aspects of the dam that have been analyzed include: changes in the area irrigated; changes in the supplies of electric power; changes in yields and production technology (primarily changes in fertilizer consumption and the use of High Yielding Variety seeds).

As elaborated in Table 1 above, for estimating a project multiplier value for the Bhakra dam, for the numerator, we need to estimate the regional value added (for the Punjab state) under 'With Project' situation as well as the regional value added under 'Without Project' situation. For the denominator, we need to estimate the value added from the sectors that are directly affected by the major outputs of the dam (namely agricultural output and hydro electricity). The regional value added under 'With Project' situation has been estimated by using the SAM-based multiplier model . (Used GAMS (General Algebraic Model System) to obtain optimum solutions). The model has been used to estimate the SAM

Table 4. Estimated gross value of output and value-added in simulation exercises using the SAM model for Punjab: 1979-80 (millions of Indian Rupees)

	Gross value of Output			Value Added		
Sectoral Aggregation	Without Project	With Project	% Change	Without Project	With Project	% Change
Agriculture	15137	22072	46	9870	14398	46
Animal Husbandry	5583	7976	43	3919	5598	43
Agro Processing	3734	5566	49	473	727	54
Manufacturing	17790	21884	23	3866	4767	23
Electricity, Gas and Water	824	1647	100	473	946	100
Construction and Services	27501	30148	9.6	14277	15943	12
Total	70568	89294	26.5	32878	42379	29

coefficients for each household category and for each production sector. These SAM coefficients have then been used to estimate the regional value added under 'Without Project' situation by fixing the outputs of sectors directly affected by major outputs of the dam, namely irrigation and hydropower. Value added of sectors directly affected by the project has also been estimated from the SAM model. The agricultural sectors directly affected by the project for which the outputs have been fixed are: wheat, rice, sugarcane, cotton, gram and other agriculture. The values of agricultural output and electricity sectors under the 'Without Project' situation have been estimated under a variety of assumptions regarding availability of canal irrigation, groundwater pumping and hydro power and the technology choices affecting area and yield of major crops. To assess the likely scenario of agricultural production in the 'Without Project' situation, a Linear Programming (LP) model was formulated. The estimated production of various agricultural commodities so derived from the LP formulation, suitably aggregated to correspond with the agricultural sectors defined in SAM, were fed in to the SAM model. Assuming that identical input-output relationships hold (as under 'With Project') situation, the impact of changed agricultural production on other sectors of the regional economy have been estimated using the SAM-based fixed price model.

Table 4 presents the results of the gross value of output and value added under with and without project scenarios while Table 5 presents the results of multiplier analysis for the Bhakra dam discussed above. Estimated gross output levels and value-added are presented from simulations under 'Without Project' situation using the SAM model for the Punjab in 1979-80.

The simulation results based on a SAM model show that the Bhakra dam project generated significant indirect or downstream effects in the Punjab state. The estimated multiplier value of 1.90 imply that for every rupee (100 *paise*) generated directly by the project, another 90 *paise* were generated in the region as downstream or indirect effects. These multipliers include the effects of inter-industry linkages as well as the consumption-induced effects but does not include the benefits reaped in by other players such as immigrant labor etc. If it were possible to account for these impacts as well, the value of multiplier would perhaps be much larger than estimated.

Table 5. Estimated values for multiplier effects of the Bhakra dam project, India

Definition of Multiplier	$\dfrac{\text{Direct Effects + Indirect Effects}}{\text{(Direct Effects)}}$
Value (Millions of Indian Rupees (Rs))	$\dfrac{\text{Regional Value Added (with Project)} - \text{Regional Value Added ('Without Project')}}{\text{Value Added of Ag. \& Elec. (with Project)} - \text{Value Added of Ag. \& Elec. ('Without Project')}}$ $\dfrac{42379 - 32878}{15343 - 10343} = 1.90$

8. INCOME DISTRIBUTION IMPACTS ESTIMATED FROM THE SAM-BASED MODEL

As explained above the households in the SAM formulation have been divided in to five household categories. To assess the impact of the benefits emanating from dam on different categories of households, the SAM-based multiplier model has been used to assess the differences in household incomes under 'With' and 'Without Project' situations. Table 6 shows that all households have higher income levels under 'With Project' situation than under 'Without Project' situation. For example, for the self-employed rural households, the difference in income levels (under 'With' and 'Without Project' situations) is estimated to be Rs 3680 million. Their income under 'With Project' situation is 42 per cent higher over the income level under 'Without Project' situation (Rs 8825 million). In the case of agricultural labor households, the difference in income is Rs 1580 million, which shows that their income under 'With Project' situation is 65 per cent higher than the income level of Rs 2425 million under 'Without Project' situation. However, in the case of urban households, the difference in the income levels under the two situations is relatively low, only 16.5 per cent. The level of income of urban households under 'Without Project' situation is Rs 14014 million compared with Rs 16331 million under the 'With Project' situation. The results show that the gain for rural households from the dam is relatively higher than the average difference of 29 per cent between aggregate incomes under 'With' and 'Without Project' situations. Further, the investment in the Bhakra dam has provided income gains to agricultural labor households that are higher than those for the average households.

Table 6. Differences in incomes of agricultural labor and other rural households : With and without Bhakra dam

(Rupees Million)

Category of Households	With Project	Without Project	Difference	Percent
Self employed rural households	12505	8825	3680	41.7
Agriculture labor	4005	2425	1580	65.2
Rural non agriculture	1125	627	498	79.5
Rural-others	8413	6988	1425	20.4
Urban households	16331	14014	2317	16.5
Total	42379	32878	9501	28.9

REFERENCES

Bell, C., Hazell, P. and Slade, R. (1982). The project evaluation in regional perspective – A study of an irrigation project in Northern Malaysia.

Bhalla, G.S., Chadha, G.K. Kashyap, S.P. and Sharma, R.K. (1990). *Agricultural Growth and Structural Changes in Punjab Economy: An Input-Output Analysis*. IFPRI, Washington DC.

Bhatia, Ramesh and Malik, R.P.S. (2004). Indirect economic impacts of Bhakra multipurpose dam, India. In : *Indirect Economic Impacts of Dams,* Bhatia, Ramesh, Rita Cestti, Monica Scatasta and R.P.S. Malik (Eds.) 2007. The World Bank (forthcoming).

Decaluwé, B. and Martens, A. (1988). CGE modeling and developing countries: A concise empirical survey of 73 applications to 26 countries. *J. Pol. Model*, **10,** 529-568.

Devarajan, S., Lewis, J.D. and Robinson, S. (1990). Policy lessons from trade-focused, **12(4):** Two-sector models. *J. Pol. Model*, 625-657.

Devarajan, S., Lewis, J.D. and Robinson S. (1986). *A Bibliography of Computable General Equilibrium (Cge) Models Applied to Developing Countries.* Working Paper No. 400, Division of Agriculture and Natural Resources, University of California, Berkeley.

Gopalakrishnan, M. (2000). The role of large dams in India. Paper presented at the International Conference on Sustainable Development of Water Resources, New Delhi, November 27-30.

Haggblade, S., Hammer, J. and Hazell, P. (1991). Modeling agricultural growth multipliers. *Amer. J. Agric. Eco.*, **73(2),** 361–374.

Robinson, S. (1989). Multisectoral models. In : *Handbook of Development Economics*, H. Chenery and T. N. Srinivasan (Eds.) Vol. II., Elsevier Science Publishers, Amsterdam.

WCD (2000). *Dams and Development: A New Framework for Decision-Making.* The report of the World Commission on Dams, issued on November 16, 2000, available at www.damsreport.org

World Bank (1996). The World Bank's Experience with Large Dams – A Preliminary Review of Impact. Operations Evaluation Department, Report No. 15815, The World Bank, Washington, D.C.