GROWTH IMPACTS OF DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

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Abstract

The paper presents the hypothesis that investments in development and management of water resources impacts all round growth - not only in the sectors and regions impacted directly by the availability of water but also in sectors and regions impacted indirectly by the availability of water. The indirect economic impacts can be as large as the direct economic impacts and therefore evaluating growth impacts of water resources projects based solely on the direct impacts can seriously underestimate the true growth impacts. The author supports the hypothesis by analyzing the Bhakara Nangal Project in terms of the direct and indirect economic and developmental impacts it has on the economy at large, including all sections of society, including the poor.

1. NATURE OF WATER GROWTH INTER-RELATIONSHIP

Water impacts growth and is impacted by growth. Water has both been an important driver of and a contributor to the process of growth. Investment in water resources has often formed the basis of investment in other growth inducing activities and programs. To illustrate, provision of water, such as in the case of irrigation water, fundamentally alters the agricultural environment permitting agricultural response along a more productive and intuitively more elastic production function. Availability of irrigation is not only accompanied by technological and other changes at the farm level, state level and district level but also by development of other infrastructure such as road, credit, marketing, electrification, schooling etc. Productivity improvements and related changes brought about by irrigation translate into income improvement per unit of land, influencing income levels and poverty. Investments in water resources has often formed the basis of broad regional and national development as witnessed in many OECD countries (Japan, the Netherlands, Norway, Spain, the western United States) and developing countries (among them Brazil, Egypt, Mexico, India, Pakistan, South Africa and Thailand) and benefits of growth of such investments in water resources have been shared by all sections of the economy and society.

Water impacts growth in a myriad of ways and in all its dimensions. Water impacts growth both positively and negatively, directly and indirectly, locally and regionally, independently and conjunctively, tangentially and substantially, at the level of an individual sector and at the multi sectoral level. The intended growth impacts of water use in a specific sector or in a specific geographical location are generally not restricted to that sector or that geographical region alone but these impacts reverberate through inter-sectoral and inter-regional linkages to other sectors of the economy and over a much larger spatial scale. All forms of water resource development – single or multipurpose, large or small, targeted or untargeted, surface water or groundwater based – and its use have impacted the growth of different sectors of the economy.

Apart from the apparent contribution of water to growth, water has also impacted growth through its linkages with energy. Water-energy linkages and interdependencies have contributed to the growth both through generation of energy and also through use of energy for making groundwater available. Water is required not only for generating hydropower, water is an essential input for generation of thermal and nuclear power as well. About one-third of total electricity in India is used for pumping groundwater for irrigation as well as for domestic water supply in urban and rural areas. The presence of strong inter linkages between water and growth, water

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and energy, and energy and growth have to be harnessed and translated into mutually reinforcing and much stronger and forceful inter-linkages between water, energy and growth.

Water, impacts growth not only through the investments in water resource development, but also investments in more efficient management of water resources. The changes in the policies governing the use of water and its allocation, in isolation and/or in conjunction with investments in water resources, can have substantial impacts on the economic growth and poverty. The empirical evidence linking the 2 is however scarce and sketchy.

Concurrent with growth contributing impacts of water, water has also sometimes been responsible for retarding growth. Floods year after year cause widespread loss to life and property, severely affecting the poor. The use of fertilizers and other chemicals in irrigated agriculture have both on and off site impacts on water quality. The excessive withdrawals of ground water, beyond their sustainable yield levels, have implication for water availability, water quality and agricultural sustainability. The larger industrialization has implications for water quality deterioration through effluent discharge in streams and rivers. The development of large-scale surface water infrastructure has implications for forest submergence, displacement of people, in causing water logging and soil salinity and in spread of water borne diseases. Some of these negatively impacting effects of development and use of water on growth can, however, often be minimized through adoption of appropriate policy, management and technological interventions.

2. OBJECTIVES AND SCOPE

While there is enough theoretical, commonsensical and circumstantial reasoning to substantiate and empirical support to demonstrate that investments in development and management of water triggers growth in multifarious ways, because of the complex interactions water induces in isolation and in combination with other policies and development investments, there are methodological issues relating to quantifying and isolating the contribution of water on various growth variables. An attempt has been made in the present paper to demonstrate how the diverse growth inducing economic impacts of water can be quantified with a reasonable degree of precision. The paper briefly presents results in respect of growth inducing impacts of investments in development and management of water resources from three recent case studies with which the author was associated. To demonstrate how the growth impacts of large scale multipurpose water resources development projects may differ from small scale projects, we analyze the growth implications of both types of projects. We estimate the regional growth impacts of a large project - Bhakra multipurpose dam located in the North-West India. We also estimate the growth impacts of a small check dam constructed in Village Bunga in the Shivalik hills region in the state of Haryana. For demonstrating the growth implications of management of water resources, we have selected Tamil Nadu, a state which is in the grips of acute water scarcity.

Before presenting evidence to demonstrate the growth implications of development and management of water resources, it is important to briefly elaborate on the meaning of growth in the present context and how this has been measured in the present paper. In general growth is a multi dimensional variable and encompasses economic, social and environmental concerns. Water impacts growth in all its constituents. The multifarious nature of impacts of water traverse through a mesh of processes and pathways culminating in to multi dimensional growth impacts of water. While for measuring growth, several indicators of growth can be employed depending upon the purpose at hand, for the present paper we measure the economic growth impacts of water in terms of increase in regional value added.

3. GROWTH IMPLICATIONS OF WATER RESOURCES DEVELOPMENT : LARGE PROJECTS

The Bhakra dam system is a large multipurpose water resource project in north-west India producing several benefits including water for irrigation, domestic and industrial sectors; hydro power for industries, agriculture and households; flood control; recharge of groundwater, tourism, fisheries and other non-irrigation benefits of canals. The availability of irrigation water through the dam-canal network of Bhakra dam system and the groundwater pumping facilitated by recharge from the system over the last 50 years or so has helped in bringing large tracts of cultivated area in the region under irrigation. The availability of surface irrigation water from the Bhakra dam system and from groundwater pumping in the area provided impetus to the adoption of high yielding varieties of rice, wheat and cotton and in promoting use of chemical fertilizers. Adoption of this technological package transformed the agricultural production scenario in the region leading to higher crop yields. This has contributed significantly to the increases in output of agricultural commodities. In addition, the hydro power stations installed in the Bhakra system have a combined generating capacity of 2880 MW, which currently generate about 14000 million units (kWh) of electricity in a year.

The direct economic impacts, in terms of additional agricultural output and hydro power, generated by the availability of water, in turn have led to generation of both inter-industry linkage impacts and consumption-induced impacts on the regional and national economy. These impacts, often referred to as indirect economic impacts, operate as follows : water released from the multipurpose dam provides irrigation that results in the increased output of agricultural commodities. Changes in the output of these commodities require inputs from other sectors such as seeds, fertilizers, pump-sets, diesel engines, electric motors, tractors, fuels and electricity. Further, increased output of some agricultural commodities encourages setting up of food processing (sugar factories, oil mills, rice mills, bakeries) and other industrial units. Similarly, hydropower produced from a multipurpose dam provides electricity for households in urban and rural areas and for raising of industrial outputs (e.g., fertilizers, chemicals, machinery). Changes in the output of these industrial commodities require inputs from other sectors such as steel, energy, chemicals, among others. Thus, both increased output of electricity and irrigation from the dam results in significant backward linkages (i.e., demand for higher input supplies) and forward linkages (i.e., providing inputs for further processing).

Increased outputs of industrial and agricultural commodities generate additional wages and incomes for households. Higher incomes result in higher consumption of goods and services that, in turn, encourage production of various agricultural and industrial commodities. Changes in wages and prices have both income and substitution effects on expenditure and saving decisions of different owners of factors of production, which further impacts the demand for outputs both within the region and throughout the economy. Induced impacts reflect the feedbacks associated with these income and expenditure effects, and also include any impacts of changes in government revenues and expenditures that resulted from the project. The level of indirect impacts of a dam on the regional economic and value-addition however depends upon the strength of linkages among various sectors of the economy.

These direct, indirect and induced growth impacts of any large multipurpose water resources project are evident to any keen observer of the situation prevailing before and after the construction of the dam. However while evaluating the growth impact of such projects only the direct impacts are generally considered and these indirect and induced impacts are almost never taken into account. While fully appreciating and recognizing the existence of such indirect and induced economic impacts, one of the main reasons for not taking in to account these impacts of dams has often been the lack of data and an appropriate methodological framework for quantifying them.

The analytical tools that can be used to assess indirect and induced impacts of exogenous changes – be these demand shocks, policy changes, or the introduction of large projects with potential for such “spillover” effects – fall into the broad category of multi-sector models. A continuum of such models exist, differing primarily with respect to (i) their assumptions regarding quantity vs. price-responsiveness to exogenous shocks, (ii) the focus on income levels vs. the inclusion of distributive considerations, (iii) their capacity to incorporate factor and import substitution possibilities, and (iv) their capacity to accommodate policy distortions, specific factor and output market structures, and other peculiarities.

A number of analytical tools for estimating these multiplier effects have been suggested in the literature (Bell *et al., 1*982; Hazell and Ramasamy, 1991; Haggblade *et al.*,1991; Hoffman *et al.*,1996; and Aylward *et al.*,2000). These tools, which are essentially in the nature of multi-sector models, include: (i) Input-Output (I/O) Models; (ii) Social Accounting Matrices (SAM) based models; and (iii) Computable General Equilibrium (CGE) models.

From the point of view of the analysis of indirect and induced impacts of dam projects, the choice of an appropriate analytical tool need 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. 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[2] 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.

Often the selection of a suitable analytical tool for multiplier analysis of a dam critically depends on the availability of I/O tables or SAM databases and models for a region. Based on the above considerations, for estimation of the indirect and induced impacts, we have employed a SAM based fixed price multiplier models in conjunction with mathematical programming models.

Thus combining an analytical framework of optimizing models with a Social Accounting Matrix (SAM) based fixed price multiplier model, the present study on Bhakra dam system has attempted to quantify the direct and indirect aggregate economic impacts of the Bhakra dam[3] for the state of Punjab[4] (Bhatia and Malik, 2008). The SAM framework provides a consistent, comprehensive, and detailed picture of the transactions in the economy and provides a basis for the construction of a model of the regional economy that is used to estimate the direct and indirect effects of a project. 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 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). 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. This analysis captures the main effects of the dam during a typical year during its lifetime, say 1979-80, approximately 20 years after the construction was completed. The choice of year for analysis in large part has been dictated by the availability of requisite data which was available from a detailed study (Bhalla et al., 1990). In measuring the impact of the project, an attempt is made to assess the situation in the region (the Punjab state) for the hypothetical case of 1979-80 in the absence of the project. This has been done by assuming that all autonomous changes in the region 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.

3.1 Differences in aggregate value - added under 'Without Project' and 'With Project'

The results obtained show that, in 1979-80, the aggregate gross output in the region under the 'with project' situation was larger by Indian Rupees 19 billion[5] (27%) than it would have been had the project not been constructed. As expected, the project had its biggest impact on the output of agricultural commodities, specially

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[2]A Social Accounting Matrix (SAM) can feed into a standard CGE model .

[3]The benefits of water from the Bhakra dam systems extend over Punjab, Haryana, Rajasthan and Delhi while the benefits from hydropower generated by the dam extend over a much larger area. For the purpose of estimating the direct and indirect economic impacts in this paper we have however restricted the analysis to the state of Punjab alone. If these estimates were to be generated for the entire project benefited area, these impacts would be much larger..

[4] The Punjab state accounts for 41%of the total irrigated area in the Bhakra command and for 38% of the total electricity generated in the Bhakra system

[5] This is roughly equivalent of US $ 2 billion at the prevailing exchange rate in 1979-80. The current (2005) exchange rate is Rs. 45/ US dollar.

the output of wheat, paddy, cotton and oilseeds. The output of agricultural commodities was larger by Rs. 7 billion (61%) under 'with project' situation than it would have been had the project not been undertaken. The output of electricity was estimated (for 1979-80) to be higher by 6033 million kWh or Rs. 1442 million.

Further, the results on value added obtained from an analysis of the model show that in 1979-80, the aggregate value added in the Punjab economy under 'with project' scenario at Rs. 42.4 billion was higher than the value added under 'without project' scenario by Rs. 9.5 billion or by about 29% (Table 1). Of this, the value added from sectors affected directly by the project (agriculture and hydro power) at Rs. 15.3 billion was higher than the corresponding value added under 'without wroject' scenario by Rs 5.0 billion. This shows that the value added in sectors directly affected by the dam (agriculture and hydro power) was almost 49% higher under 'with project' situation than 'without project' situation. The value added by sectors indirectly impacted by the dam was higher by Rs. 4.5 billion (about 20%) in the with project scenario as compared to without project scenario. Thus in absolute terms the increase in value added by sectors indirectly impacted by the construction of dam was almost as large as that by the directly impacted sectors.

Table 1: Growth Impact of Large Water Resources Project: Differences in Regional Value Added under 'With Project' and 'Without Project' Situations for Bhakra dam system in Punjab 1979-80 (in Rupees Billion)

Sectors/Total	With Project	Without Project	Difference (With Project over Without Project)
Sectors directly affected by the Bhakra dam system (Irrigation and hydropower)	15.3	10.3	5.0 (48.9%)
Sectors indirectly affected by the dam system	27.1	22.6	4.5(19.9%)
Total	42.4	32.9	9.5(28.9%)

3.2 Distribution of Gains : Income Distribution Impacts

The SAM model employed for estimating the direct and indirect economic impacts of Bhakra dam distinguishes five categories of households – self employed farming households, agricultural labour households, rural non-agricultural households, rural other households and urban households. The results of the analysis enable us to assess the differential impacts of changes the construction of the dam had brought about on different categories of households. The income distribution impacts of the Bhakra dam have been analyzed by comparing the differences in aggregate income levels of various household categories under with and without project scenarios and by assessing direct and indirect components of income differences under the two situations. Figures 1 and 2 summarize the results obtained.

The results obtained signify that:

a. The construction of Bhakra dam system provided income gains to all the categories of households, including the urban households and the percentage increase in income of agricultural labor households is higher than that of landed households. This poorest group (agricultural labor) gained a 65% increase in income as compared to a rural average increase of 38% (under the 'with project' scenario as compared to the hypothetical 'without project') scenario.

b. The gains from the dam to different categories of households emanate from different sources. While landed households, agricultural labor and rural non agricultural labor households derive larger gains from the sectors directly affected by the project, the other rural households and urban households derive larger gains from indirectly impacted sectors.

Figure 1: Income of Different Types of Households With and Without Bhakra Dam, India

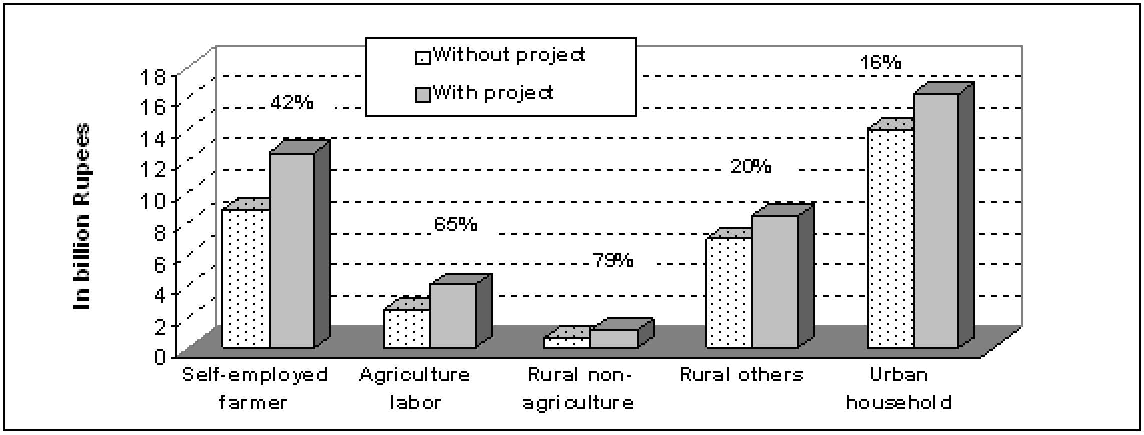
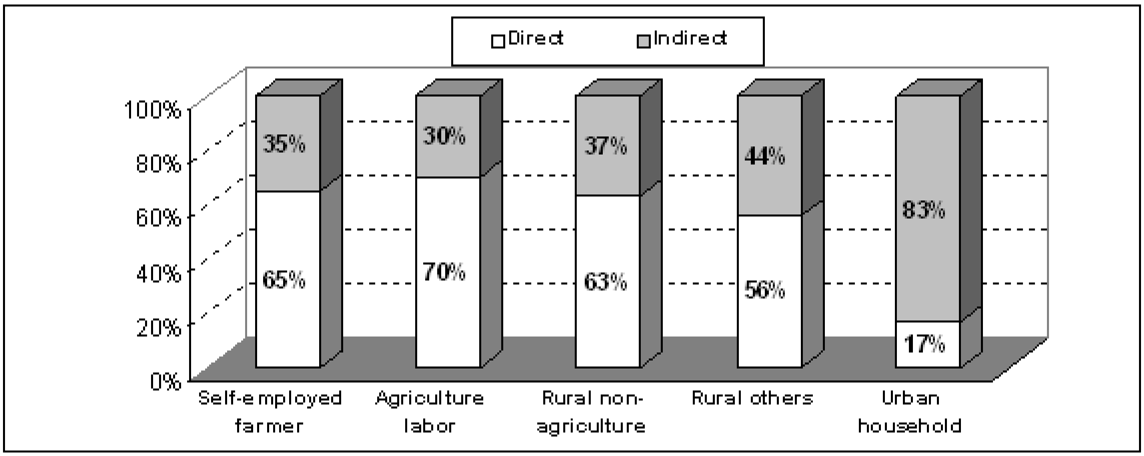


Figure 2: Income Gains to Households by Sectors Affected Directly and Indirectly by the Bhakra Dam, India



3.3 Indirect Economic Impacts in Other Regions

Apart from direct and indirect economic impacts accruing to both rural and urban households as also to landed and labor households within punjab, the water made available by the construction of the dam also impacted other regions of the country. The huge production of food-grains in the region created vast quantities of marketed surplus of these grains. The procurement agencies of the Central government every year purchase huge amounts of this marketed surplus of food-grains for maintaining the national buffer stock of food-grains and running the Public Distribution System (PDS) of the country through a distribution network of hundreds of ration shops spread all over the country. For example, during the year 2004-05 the states of Punjab and Haryana contributed 12.4 million ton of wheat out of a total of 16.8 million ton procured by these agencies from all over the country. Similarly, during the year 2004-05 out of a total procurement of 24 million ton of rice from the entire country, Punjab contributed 9 million ton while Haryana contributed 1.7 million ton. Thus, huge marketed surpluses generated by the Bhakra dam command provided food-grains to the urban poor, at prices they could afford, in other regions of the country.

The shifts in the cropping pattern and attendant changes in crop production brought about by the availability of irrigation water in the region created employment opportunities in the agriculture and related sectors. The huge employment opportunities available on a continuing basis for hired labor every year lures thousands of labourers from far off poor regions of the country (Bihar, Uttar Pradesh) where wage rates are low and unemployment is very high, to migrate to this region in search of employment and better wages. While some of these labourers have settled down permanently in the region itself, others migrate every year. For example, in a study carried out by Punjab Agricultural University, it has been estimated that during the lean period of agricultural operations the number of migrant labors employed in Punjab was 387 thousand and this number increases to about 774 thousand in the peak period. About 93% of the migrants belonged to the poor states of Bihar and Uttar Pradesh while about 5% also came from Nepal. It has further been estimated that the number of migrant labourers have increased by about 35% in 1995-96 as compared to 1983-84 and the Punjab agriculture managers almost one tenths of its total labor requirement from migrant workers.

The wage rates which these migrant laborers were getting in their native villages were lower as compared to what they got in Punjab. Thus, for example, about 46% of the migrant labor were getting less than Rs. 300 per month for being employed on a permanent basis in their native villages while in Punjab they were getting almost 200% higher wages.

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%) back to their native places while the remaining Rs 1796 (US$ 39 million) were spent by them in Punjab itself. About 18% of the migrant labor utilized their savings for creation of assets in their native places (Sidhu et al., 1997).

4. GROWTH IMPLICATIONS OF WATER RESOURCE DEVELOPMENT : SMALL PROJECTS

Concurrent with development of large water resources projects, such as Bhakra dam system discussed above, a greater emphasis is now being placed in encouraging development of community-managed small check dams. As a result, a large number of such dams have been constructed during the last two decades. These check dams provide water for irrigation, livestock and human beings and have contributed significantly to the increase in income of villagers and others around these villages.

In a small village Bunga, located in the Shivalik hills region near Chandigarh, 2 such check dams were built – the first in 1984 and the second in 1996. These dams have been providing irrigation to about 276 hectares of land in this small village with a population of 178 families (1100 persons). In addition to the direct increases in the gross irrigated area, output of food-grains and fodder, the check dams have created some indirect economic impacts (milk production and sale; shops and trading in the village, sale of grass etc) that has increased the income levels of almost all the households in the village.

Adopting an analytical framework somewhat similar to that discussed above in the case of Bhakra dam, a Social Accounting Matrix (SAM) based analytical model was developed to estimate the direct and indirect economic growth impacts of making irrigation water available in the village through these check dams (Malik and Bhatia, 2008).

4.1 Differences in aggregate value- added under 'Without Project' and 'With Project' in Bunga village

The results show that in 2001-02, the aggregate value added in the village economy under 'with project' scenario at Rs 10.24 million was larger than the value added under 'without project' scenario by Rs. 3.48 million or by 52% (Table 2). out of this, the value added from sectors affected directly by the project at Rs. 4.71 million was larger than the corresponding value added under 'without project' scenario by Rs. 2.48 million. This shows that the value added in sectors directly affected by the dam (food crops, fodder and income from sale of water) was more than double (higher by 110%) under 'with project' situation than 'without project' situation. The value added by sectors indirectly impacted by the dams was about 22% higher in the with project scenario as compared to without project scenario. In the aggregate, the project induced an increase of Rs. 3.48 million in regional value added. Of this, Rs. 2.48 million (or 71%) was due to increase in the outputs of sectors directly affected by the Bunga dam and the remaining Rs. 1 million (or 29%) was due to sectors indirectly impacted by the construction of these check dams.

Table 2: Growth Impact of Small Water Resources Project : Differences in Regional Value Added under 'With Project' and 'Without Project' Situations for Bunga in 2001-02 (in Rupees Million)

Sectors/Total	With Project	Without Project	Difference (With Project over Without Project)
Sectors directly affected by the check dam (Agriculture and fodder)	4.71	2.23	2.48 (110%)
Sectors affected indirectly by the dam (Milk production, other incomes from trade etc.)	5.53	4.53	1.00 (22%)
Total Value Added (Direct and Indirect)	10.24	6.76	3.48 (52%)

Source: Simulations using SAM for Bunga. See Malik and Bhatia (2008).

5. GROWTH IMPLICATIONS OF MANAGEMENT OF WATER RESOURCES

It is not the development of water resources alone that can and has contributed to growth, both directly and indirectly. Investments in management of water resources in isolation or in combination with development of water resources can be equally effective in contributing to the process of growth. The empirical evidence linking the two is however very sketchy and scarce. In a recent study in Tamil Nadu we have attempted to demonstrate how management of water resources can help not only added to but accelerating the process of growth. The study analyses the growth implications of a switch in water management practices from a system of command-and-control water allocation policies to a more flexible allocation policies, which facilitates the re-allocation of the limited quantity of available water from low- to high-value uses (Bhatia et.al., 2006).

The state of Tamil Nadu has a population of about 62 million people, of which 55% is urbanized. The state is in the grips of a water crisis. Even though total water resource potential of the state is about 46540 million cubic meters (MCM), the water availability per capita is less than 500 cubic meters per year, well below the 1000 cubic meter figure generally considered to signal water scarcity. The current level of water availability and usage clearly shows that Tamil Nadu has been using up almost all its available water and there is no water available to support larger demands from any of the sectors without harming the interests of the other sectors from where the water is diverted. However, the current pattern of availability and use of water should not be construed to imply that the different sectors are able to meet their required demand for water or that water availability to different sectors is reliable, timely and of desired quality. In fact the current demand for water from all the sectors put togather far exceeds the available supply. In many ways, the state is well on the road to a situation that other states in India could face in the coming years. These implicit quantitative and qualitative shortages have resulted in huge hidden costs and production, efficiency and income losses, the extent and magnitude of which are unknown and have never been quantified.

The response of the State to this growing water scarcity has primarily been one of attempts at supply-side augmentation coupled with some demand side management interventions. The various supply side measures attempted to augment available water include – attempt to capture a larger proportion of rainfall, by creating large and small dams and rainwater harvesting structures; try to bring more water into the state from both inter-state rivers such as Cauvery, or from other peninsular rivers such as the Krishna through the Telugu Ganga project; augment supplies for cities and industry by desalination and treating and re-use of wastewater, and through rehabilitation and modernization of tanks through external and internal funding. These primarily supply side augmentation (large and small) from sources within and beyond the state, have, in recent years been complemented with coping mechanisms on the demand side. Recent repeated droughts have forced the state to advise farmers to adopt less water intensive cropping patterns and more efficient irrigation systems. Tamil Nadu has set national precedents in mandating rainwater harvesting in cities and towns to recharge groundwater. The impact of these supply side and demand side interventions has been mixed but minimal in overcoming the water scarcity problems in Tamil Nadu. While these supply side and demand side interventions will need to continue to cope with water scarcity, these interventions will have to be supplemented by more efficient allocation and management of the available water.

As per the Tamil Nadu Water Policy (1994), "water allocation priorities in the planning and operation of systems should be broadly as follows: (i) Drinking Water, (ii) Irrigation, (iii) Hydropower, (iv) Industry and other uses. However, these priorities might be modified, if necessary, in particular tracts with reference to area-specific considerations." This official prioritization of water use has, however, seldom been effective in practice. As in any other state in India, effective institutional mechanism and the political will to enforce the sectoral prioritization envisaged in the policy do not exist. While the state policy gives priority to water for drinking, in practice the drinking water availability in Tamil Nadu is woefully inadequate. Probably the worst drinking water availability situation exists in the State's capital city of Chennai.

5.1 The Increasing Demand for Water in Tamil Nadu and the Likely Supply Scenario in 2020

It is estimated that by 2020 the population of the state will increase to 77.8 million, the rate of urbanization will increase substantially, the economy will continue to grow at the rate of at least 7% per year, and the per capita incomes will increase considerably. These changes in population and economic scenarios will have implications for water demand: the demand for water is also expected to increase correspondingly over this period. In the absence of any new known sources for supply of fresh water, the availability of water is unlikely to undergo any significant change during this period. It is estimated that the availability of surface water supplies are likely to reduce over time due to sedimentation of reservoirs and catchments related issues. Over a 20 year period, a 5% reduction in supply of reservoir water and a 10% reduction in the supply of tank water is likely to occur on account of these factors. However, given the likelihood of future inter-basin water transfers, it is estimated that by 2020, 1600 MCM of additional water is likely to be made available from the Godavari-Cauvery link and about 634 MCM through the Pamba-Vaippar link as per the estimates given by the National Water Development Agency (NWDA). Given the gap between current withdrawals and the estimated groundwater potential in 2020, estimated at 19800 MCM, the availability of groundwater is likely to increase. The other supply side augmentation options such as through rainwater harvesting, through improvement in basin wide water use efficiency, through adoption of high cost solutions such as desalinization of sea water, possibility for additional water through inter-linking of inter-state rivers etc are likely to be either very slow to come by due to economic, administrative and financial considerations or are likely to be masked to a great deal by politics and impasse over water transfers. As a result, in aggregate terms these options are unlikely to add any substantial quantities to the water supply available from traditional sources during the envisaged period. As such any possible addition to water availability from such options, though likely and welcome, has not been considered in the present assessment. The estimated total water availability during 2000 and 2020 from different sources in Tamil Nadu is given in Table 4 and Figure 3. Thus, while the total water availability during this period is likely to increase by about 23%, mainly on account of increased groundwater withdrawals, the water availability from surface water sources is likely to decline substantially.

5.2 Towards Some Management Solutions

Given the estimated availability of water in 2020 and the impacts the changing economic and population scenarios in Tamil Nadu are likely to have on the demand for water, will the command and control approach to water management as envisaged in the State Water Policy be able to ensure a rational allocation of water between the competing water using sectors without seriously hampering the economic growth and adversely affecting the interests of the vulnerable sections of the society? What is the trade-off involved in adopting a more forward looking approach to water allocation and use? To evaluate the likely implication of adopting a more flexible water allocation on the Tamil Nadu economy, we formulate the following alternative scenarios:

2.2.3 Fixed water allocation

This assumes continuation of current priorities in water allocation to year 2020. The future allocation and use is based on maintaining the shares of water in agriculture, domestic, industry at the ratios prevailing in the base year of 2000. Additional supplies of sustainable groundwater are allocated amongst the different water using sectors in the same proportion as in 2000.

2.2.2 Flexible Water Allocation

This scenario is based on reallocation of available water amongst agriculture, domestic and industry based on economic value of water in these sectors. The overall volume of water available in the base-case scenario remains the same as in 2000 but water is allocated (by the optimization model) to all sectors based on the estimated economic value of water in each sector (as defined by the willingness to Pay (WTP) for water in each sector). It is assumed that control structures for water redistribution amongst various users are in place and incentives to transfer water from one use to another will be present. However, due to considerations of livelihood and food security at the local level, basin-wise lower bounds have been put for area under food crops at a level equivalent to 50% of the area under these crops in the year 2000. Similarly, for industry, lower bounds for output have been placed at 2000 level at the basin level. Both agricultural and industrial outputs are constrained, through upper bounds, at a level equivalent to their exogenously projected output level in 2020 at the State level.

The estimated direct and indirect economic impacts of shifting from a fixed water allocation scenario to a more flexible water allocation scenario were estimated in terms of

(i) Comparison of total gross value of output in the two scenarios

(ii) Comparison of value added or state income in the two scenarios

To assess the direct impact of water allocation amongst different water users and to assess the economic value of additional water, basin-specific optimization models were developed. For each of the 17 basins[6], a single-period Linear Programming Model was developed which (a) takes into account exogenously-set water allocations for ecological, environmental and in-stream uses (which are varied in different scenarios) and (b) then determines the economically-optimal allocation of water amongst alternative water using sectors (agriculture, industry and domestic) and amongst alternative choice variables (different crops, levels of service and industries) within the individual water using sectors. The Social Accounting Matrix (SAM)- based multiplier model (that incorporates the input-output model) takes the results of the optimization models as inputs, and then determines the aggregate (direct plus indirect) impacts of different scenarios.

5.3 Comparison of Gross Value of Output in the Two Scenarios

If one were to adopt more flexible water allocation policies, the gross value of output (GVO) in Tamil Nadu in 2020 is likely to be higher by about 40% (from Rs 9925 billion to Rs 13878 billion at 1999-00 prices) in comparison to the policies of rigid allocation of water (Table 3). A closer examination of the changes in the sectoral GVO suggests that as a result of adoption of such water using policies while the GVO of agriculture is likely to go down by about 27%. But that of industry and electricity and gas are likely to increase substantially. The GVO of industry is likely to go up by about 119%. The tertiary sector output is likely to increase by about 14%.

5.4 Comparison of Value-Added[7] or State Income in the Two Scenarios: 2020

Due to differences in the ratio of gross value added (GVA) to GVO across and within different sectors, the magnitude of changes in GVA in the flexible scenario are likely to be somewhat different from those of GVO.

[6] The model does not consider the possibility of inter-basin transfer of water since inclusion of such an option would require making assumptions about the availability of institutions and physical infrastructure to undertake these transfers. Though such a transfer is possible in the long run for the present exercise this option has not been included.

[7] For the purpose of this study, the sum Gross Value Added in all sectors is taken as equal to the state income

As a result, in contrast to 40% increase in GVO, the GVA in 2020 is likely to increase by 21% (from Rs. 5969 billion to Rs. 7233 billion) if more flexible water allocation policies were to be adopted (Table 4, Figure 3). While the GVA from agriculture between the two scenarios in 2020 is likely to decline by about 29%, that of industry and electricity and gas is likely to rise substantially.

Table 3 : Comparison of Gross Value of Output by Major Sectors in Tamil Nadu under the Two Scenarios: 2020 (Rs Billion)

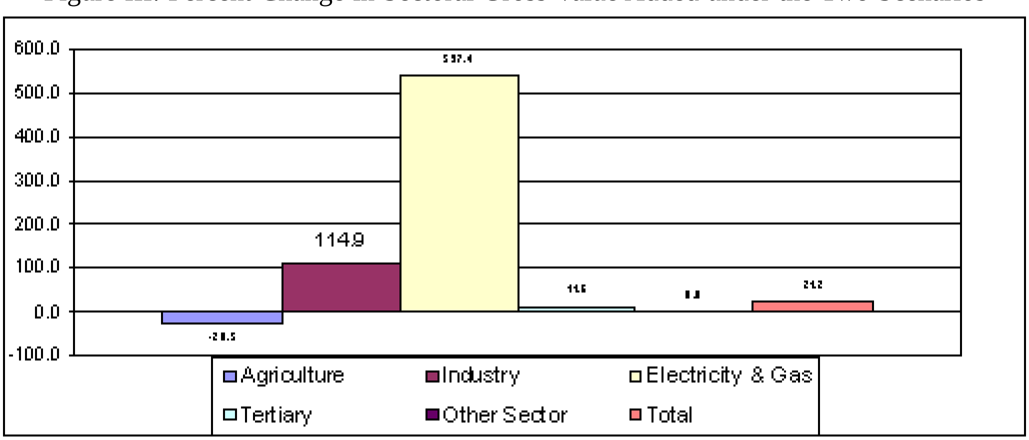
Sector	Water Using Scenarios		Percent Change
	Fixed	Flexible	
Agriculture	158	116	-26.5
Industry	1760	3851	118.8
Electricity & Gas	158	1010	537.4
Tertiary	7611	8663	13.8
Other Sector	238	238	0.0
Total	9925	13878	39.8

The value added in tertiary sector is likely to be higher by Rs. 610 Billion (by about 12%) showing the effects of indirect impacts of additional value added in industry, electricity and gas sectors. Hence, the reduction in value added or income in the agricultural sector is more than compensated for by the increases in the value added in industry, electricity and tertiary sectors.

Table 4: Comparison of Gross Value Added by Major Sectors in Tamil Nadu under the 2 Scenarios: 2020 (Rupees Billion)

Sector	Water Using Scenarios		Percent Change
	Fixed	Flexible	
Agriculture	107	76	-28.5
Industry	360	773	114.9
Electricity & Gas	51	322	537.4
Tertiary	5281	5891	11.6
Other Sector	171	171	0.0
Total	5969	7233	21.2

Figure III: Percent Change in Sectoral Gross Value Added under the Two Scenarios



6. CONCLUSIONS

The evidence presented above demonstrates that investments in development and management of water resources impacts all round growth - not only in the sectors and regions impacted directly by the availability of water but also in sectors and regions impacted indirectly by the availability of water. The indirect economic impacts can be as large as the direct economic impacts and therefore evaluating growth impacts of water resources projects based solely on the direct impacts can seriously underestimate the true growth impacts. The results on income distribution impacts of Bhakra presented above also suggest that economic gains from investment in development of water resources are not iniquitous and the economic benefits flowing there from are shared by all sections of the society including people living in the urban areas and the distribution of these benefits are such which do not leave the poor out.

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