WHO BENEFITS FROM IRRIGATION INVESTMENTS IN INDIA? IMPLICATION OF IRRIGATION MULTIPLIER ESTIMATES FOR COST RECOVERY AND IRRIGATION FINANCING[1].

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Abstract

Who benefits from irrigation development in India and who should pay the cost? To answer this question we need to know in addition to other factors the magnitude of the indirect benefits *derived by the non-farm sector from irrigation development. Using panel data from 14 states over the period 1970 to 1994, we have estimated the marginal benefits, both* direct *(farm level) and* total *(rural economy wide) derived from irrigation development. Dividing* total *by* direct *benefits of irrigation we compute irrigation* multipliers *ranging from3 to 4.5. This suggests that two thirds or more of the benefits from irrigation development have been captured by the non-farm sector, a factor which should be considered in developing a rational cost recovery and irrigation financing policy.*

1 INTRODUCTION:

Irrigation represents by far the largest investment in the agricultural sector. During the peak in construction of new irrigation systems during the 1970s and 80s irrigation accounted for as much as 50 percent of investment in agriculture. Even today, there are major investments to rehabilitate surface irrigation systems and reduce conveyance losses. Yet given the magnitude of these investments there is an appalling lack of research on incremental impact of irrigation versus other factors and particularly on *indirect (*non-farm sector) benefits of irrigation. The *indirect* benefits include income and employment effects in the agro-industry and non-farm sector of the regional economy and lower prices for food grains benefiting in particular low income consumers. There are also negative externalities associated with the irrigation, such as social dislocation and environmental damage (see in WCD, 2000). However, the focus of the study is on the scale of the positive benefits.

Who have been the actual beneficiaries of irrigation development in the recent past? Is it the farming sector alone or also the urban consumers and industrial labors and other broader sections of the society? To the degree that the non-farm sector has been a major beneficiary of irrigation development, what are its implications for setting effective financing, investment, and

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cost-recovery policies in irrigation? The main purpose of this study is to address the above questions by analyzing *direct* and *indirect* marginal benefits of irrigation.

This study uses state level secondary data from 14 states of India from 1970 to 1994 to analyze how the irrigation benefits have been divided between producers (farmers) and the overall rural economy. These 14 states account for more than 90 percent of the Indian agrarian economy. We also discuss some of the key literatures on irrigation cost recovery and key irrigation financing studies relevant to the issue of *direct* and *indirect* benefits.

2 OBJECTIVES

Central to the issue of how costs of an irrigation project should be shared among the different sectors in an economy is the question of who benefits from the resources use in irrigated agriculture. Therefore, the specific objectives of this study are:

- to analyze marginal benefits of irrigation development to the local farm community and to the regional economy in India taking into account of the impacts of other complementary policy and technology factors.

- to analyze and quantify the scale of aggregate "irrigation multipliers"-(i.e. the ratio of *total* irrigation benefits in the regional economy to *direct* benefits), and its policy implications to the irrigation financing.

The focus of the study is on the scale of *indirect* benefits of irrigation or benefits to the non-agricultural sector. We recognize that external costs of irrigation development are equally important for assessing the scale of irrigation benefits and to the financing and cost recovery policies. However, we do not attempt to cover negative external effects of irrigation in this study. Rather, the scope of the study is limited to analyze issues concerning the scale of distribution of irrigation benefits (irrigation multipliers) in the regional economy and its implications to the cost recovery.

3 RECENT ISSUES ON IRRIGATION IMPACT AND COST RECOVERY

Due largely to the growing financial burden, but also in an effort to improve the management, governments are undertaking programs to devolve operation and maintenance activities to local water-user groups. Here, the frequently used code name is *irrigation management transfer* or IMT. Closely linked to these efforts is the issue of *cost recovery and improvement of system performance.* Should farmers pay all or a portion of the investment costs? If so, then what proportion? To answer this question we need to know to what degree farmers have been the beneficiaries of irrigation investments in the past. Although not part of this study, we would also need to know the various taxes and subsidies associated with irrigation investments.

The current discussions on irrigation financing and cost recovery deal with *direct benefits*. All the recent policy documents on irrigation financing and cost recovery (such as the EU framework on water sector; World Bank water sector policy 1993 and 2003; Asian Development Bank water sector strategy document, 2001) are silent on nature and scale of *indirect benefits* of irrigation and their implications to designing the irrigation financing and cost recovery policies in a nation/region.

Feasibility and appraisal studies for irrigation projects typically assume that farmers are the sole beneficiaries since a single project will not affect the commodity price and demand and supply of other factors in the nation. But the rapid expansion of irrigation and widespread adoption of *green revolution* technology have resulted in a drop in world cereal grain prices by more than 50

percent from their 1970 levels. As a consequence food grain consumers, particularly the poor for whom cereal grains are the major source of calories, have realized most of the benefits of increased crops production. Numerous past studies have shown that the consumers (society in general) not the producers (farmers) have been the major beneficiaries of investment in agricultural research (see Alston, et al. 1995 and Alston and Pardey, 2001. But similar analyses have not been done for irrigation and as noted in the opening sentence of this paragraph, there is the widely held belief that farmers have been the major beneficiaries of irrigation investment in the past.

Mellor (2001) notes that the additions to employment in the agriculturally stimulated local non-farm sector can be as high as twice than that for farm sector, and this has a major impact on poverty reduction. Only a handful of studies have estimated the multiplier effects of investment in irrigation on the non-farm economy (such as, Bell et. al. 1982 for Malaysia, Powell et. al. 1985 for Australia, and AIA 1998 and Tollefson and Hill 1994 for Canada). The irrigation multipliers in the developed country cases are as high as 5 to 6 (Powell et al., 1985 and Tollefson and Hill, 1994). This implies that only 20 percent of the investment in irrigation is realized by the farming community in the developed countries. We would expect the multiplier numbers to be lower and the benefits to the farming community higher in developing countries due to weak infrastructure. However, no credible pieces of empirical information are available on the topic (see WCD, 2000)

Unless we know the scale of direct and indirect benefits of the irrigation, the discussion on cost recovery will be incomplete. Although it is obvious that a large if not a major share of benefits from irrigation have gone to the non-farm sector, advocates of cost recovery (or full cost recovery) ignore this point. Furthermore, although the lending agencies such as the World Bank and Asian Development Bank have been the most constant and insistent advocates of cost recovery for decades, there is no evidence of better cost recovery in irrigation, or of covenant compliance either (see this acknowledgement in the World Bank, 2003 p.24-25).

The important points here on marginal impact of irrigation, and/or positive external effect of irrigation, can be summarized as:

- given the enormous investments in irrigation over the past several decades there have been surprisingly few studies to assess the costs and benefits of irrigation at one site that also include the economy wide impact of irrigation (*indirect* benefits);

- to date studies have been focused largely on *direct* impacts but give conflicting results calling in to question the need to establish appropriate methodology;

- studies on the *indirect* impacts or positive *externalities* are urgently needed to assess the full impact of irrigation investments on employment, incomes, and poverty alleviation in the rural non-farm sector and to provide a guide to policy makers in setting realistic targets for cost recovery.

4 METHODOLOGY

Methodological problems on tracing down the *indirect* impact of irrigation in the economy, and the unavailability of the long series data have been major factors in limiting the number of studies. In India, however, the availability of a long time-series data across the states facilitates the conduct of this study.

The marginal *direct* and *total* benefits of the irrigation development in India are estimated here taking into account the complementary relationship among the factor-inputs. The focus in the analysis is on marginal changes in the benefits. *Direct* benefit of irrigation is measured by the marginal changes in gross value of crops output per hectare, and *total* benefit is measured by the

marginal change in agricultural sector GDP per capita of rural population. Details in Bhattarai, et al., 2003a and 2003b.

A. Marginal impact of irrigation and other factors: direct and indirect benefits

The typical supply function type of reduced-form empirical model is used here for analyzing the irrigation impact on temporal and spatial variation of both net state domestic product (NSDP) of agriculture sector and gross value of crop outputs, as given in equation 1.

$$AgPerf_{it} = \alpha_i + \beta_1 I_{it} + \beta_2 F_{it} + \beta_3 HYV_{it} + \beta_4 Lit_{it} + \beta_5 Road_{it} + \beta_6 T_{it} \quad \text{(eq.1)}$$

Where:

i = 1,…,n states of India t = year; 1970 =1 and 1994 =25 in state level analysis;

α_i = intercept term for state i; β_i = coefficients to be estimated

Dependent variables:

Ag. Perf $_{it}$ = Agricultural performance indicators (two variables)

(i) Per Capita Net State Domestic Product of Agriculture (NSDP).

(ii) Per Hectare Gross Value of Crop Outputs (GVO).

Explanatory variables:

I_{it}= Irrigation factor (two variables):

(i) % of gross irrigated area and

(ii) % of groundwater irrigated area;

F_{it} = Fertilizer uses per crop area (in Kg/ha);

HYVit= High Yielding Variety adoption rate (in %)

Lit_{it}= Rural literacy rate (in %);

Road $_{it}$ = Rural road density (Km/1,000 Km^2);

T_{it} = Time trend representing effects of other left out time depended factors.

Equation 1 is estimated as a linear model, which is the most flexible form of regression model. The coefficients (β_{is}) represent the impact of one unit change on the factor inputs to the net changes (contribution) in the dependent variable (agricultural performance).

NSDP of agriculture sector includes all direct and indirect agriculture sector activities (crops production, livestock, agro-industries and agro-services, etc.) in a state in any particular year. Thus, this equation measures the marginal impact of irrigation on the state level aggregate NSDP for agriculture, which captures both the *direct* and *indirect* impacts (rural economy wide impacts) of irrigation development. In India (but not in most other developing countries) the data on the Net State Domestic Product (NSDP) of agriculture are available for all the states.

GVO includes 41 crops across the 14 states. Thus, the equation measures the marginal impact of irrigation and other factors on land productivity or the value of crop output per hectare (see details in Bhattarai et al., 2003a).

B. Estimation of irrigation multipliers.

We have estimated the "irrigation multiplier", which is a ratio of marginal benefits of irrigation accrued to the region economy (both *direct* and *indirect*) to that of the benefits realized by the farmers in term of crops production (*direct* benefits). This is done by extrapolating the marginal impact of irrigation reported from the estimates of equation 1 (Table 1) to the all India level, and then deriving the total impact at the national level when one more hectare of irrigation is added in the economy (Table 2)[5]. The details are in Bhattarai, 2003a and 2003 b.

5 RESULTS:

The first part of this section illustrates the factors' affecting temporal and spatial variation of NSDP and of GVO in India. The irrigation multipliers are estimated in the later part of this section.

5.1 Marginal benefits of irrigation: direct and indirect

The marginal impacts of factor-inputs are reported in Table 1. The irrigation impact is positive and statistically significant on the temporal and spatial variation of per capita NSDP of agriculture and of GVO. A one percent increase in gross crop area irrigated (GIA/GCA) increases per capita NSDP of agriculture by about Rs. 10.48 (in 1980-81 constant price), which is equivalent to US$1.3 per capita, and with the elasticity value of 0.35 at sample mean observations. The elasticity value of irrigation impact on GVO (land productivity) is 0.12, which is lower than in the case of NSDP per capita.

[5] NSDP per capita (of rural population) is used for capturing the impact on total benefits of factors (irrigation) impact in the economy. Since, this is more appropriate for interpretation of the total income (benefits) in agricultural sector, as like that of the nomenclature of GDP per capita of a country. In this context, per capita NSDP is more appropriate than NSDP per hectare benefits because of the inclusion of non-farm and agro-industrial sector activities in the NSDP variable. The labor endowment (number of labor) then may influence the total NSDP *ceteris paribus*. But, this is not the case while deriving the direct impact of irrigation (GVO). Moreover, we have used here rural population instead of total population as rural population is more related with the agricultural activities.

Table 1. Factors responsible for variation of agricultural sector income (NSDP) and land productivity (GVO) across the states in India during 1970-1994.

Depended variable:
Eq.1. Net States Domestic Product (NSDP) of agriculture per rural capita, (in Rs/ha.) in constant price of 1980-81.
Eq. 2. Gross Value of crops output per hectare (GVO, or Land productivity) across the states (in Rs./ha) in constant price of 1993-94.

Independent Variable	Marginal impact on NSDP Model (Eq. 1)	Elasticity at Sample Mean	Marginal impact on G V outputs Model (Eq. 2)	Elasticity at Sample Mean
Time Trend	-40 (9.75)***		41 (2.21)**	
% of Gross Irrigated Area	10.48 (5.25)***	0.35	22.21 (2.38)**	0.12
% of Groundwater Irrigated Area	-2.22 (2.29)**	-0.09	9.06 (1.72)*	0.06
Fertilizer use per Cropped Area (Kg/ha)	3.37 (5.54)***	0.15	43.85 (16.33)***	0.12
HYV Adoption Rate (in %)	0.47 (0.40)		-4.40 (0.99)	
Rural Literacy Rate (%)	36.0 (9.31)***	1.10	87.2 (4.55)***	1.21
Road Density) (in Km/1000 Km^2 land)	0.15 (2.25)**	0.08	0.78 (2.05)**	0.12
% of non foodgrain crops area	10.98 (4.90)**	0.27	-------	
Adjusted R^2 (Un-weighted)	83		0.93	
Number of states Total No. of observations	14 350		14 350	

Notes: 1). Values in parentheses are absolute t-statistics; * - significant at 10 percent; ** - significant at 5 percent; *** - significant at 1 percent. F statistics of all above models are significant at 1percent.

2). All models were estimated as fixed effects panel model using Weighted Least squares methods (GLS). The GLS model was iterated to minimize the mean sum of square. The results are from converged model.

3). Elasticity value shows percentage change in the dependent variation (impact) when the independent variable changes by 1 percent point. It is unit free measure of the factors' impact with the dependent variable.

4). The average constant prices of food grains in India in 1993-94 was 2.7 times higher than that of the food prices in 1980-81.

The positive impact of groundwater on land productivity (here, GVO) in Table 1 is consistent with the past studies in India (Dhavan, 1988; Deb Roy and Shah, 2003, are some in the list). However, the groundwater impact on temporal and spatial variation of NSDP per capita is

negative and statistically significant. This model implies that the net benefit from the groundwater irrigation to the regional economy is negative, when we control for the impact of overall irrigation and other factor-inputs. This could be due to increasing negative externality in the case of groundwater compared to the canal irrigation, however, given the set up of the model we do not have a plausible answer for this negative impact of groundwater. What is more evident here is that a major portion of the benefits from the surface irrigation (canal) development is accrued to the regional economy, outside of the farm-yard. Development of canal irrigation goes hand in hand with development of several other services sector activities in a region, such as road, other infrastructural and agro-industries development. All of them significantly contribute for increasing the NSDP.

The signs of all other variables in the table 1 are as per our *a priori* expectations. Moreover, the relatively very large scale impact of rural education in both models in the Table 1 also indicates transition of Indian agriculture from subsistence based to the knowledge base farming. Rural literacy has elasticity of 1.1 with the NSDP per capita and 1.21 with the GVO. That is to say, a one percent increase in rural literacy rate would generate an additional 1.1 percent of per capita NSDP in agriculture sector and 1.21 percent of GVO (land productivity). This is a very high impact of the factor (human capital) considering the present level of return in farming and cost of rural education in India.

In addition, education expenditure is one time costs, not the variable costs type of physical inputs in the farming like fertilizers and irrigation that one has to apply regularly. The result here on larger impact of rural education on farm productivity and farm income basically reinforces the importance of *human capital, skill and knowledge* in the success of agriculture in India; and it is also consistent with the findings of the past studies such as, Schultz, (1961); Lipton et al., (2002); and Singh, (2000).

5.2 Comparative assessment of national level irrigation benefits: irrigation multipliers[6]

The information on different scale of marginal impact of irrigation (*total benefits* and *direct benefits)* allows us to estimate the irrigation multiplier operating in the economy. The two different types of irrigation multipliers estimated in this study are returns per hectare per crop season and returns per hectare per year (Table 2). Details methodology and derivations are in Bhattarai et al., 2003b.

When we extrapolate the marginal benefits of irrigation to the all India level impact, the direct benefit of irrigation to a typical farmer was US$71/ha/crop season, brought from increased crop production. This is about 52 % of the total annual marginal irrigation benefits (of $137/ha/year), when both the crops and livestock sectors[7] are included. When compared to the supply cost of the canal water, the total aggregate benefits of irrigation estimated here is about 15 % less than the marginal supply costs of canal irrigation in India, which was about US$160/ha/year (or Rs. 5,000/ha/year) [8] in 1992-93 (see Dhawan, 1999). That means, a typical farmer in India would

[6] We have only described the difference of marginal benefits of irrigation realized by the farmers from that of the benefits accrued to regional economy. In the literature, "changes in consumer surplus and producer surplus" has also been used to capture the scale of deviation of benefits of investment on agricultural across the farmers and the national economy. However, the consumer surplus and producer surplus based analysis needs different sets of data (factors' investment costs, etc.,) and information on the supply and demand elasticities than the kind of data used here.

[7] The per annum basis marginal impacts of irrigation and other factors are estimated same way but using annual production change as the depended variable. Details are in Bhattarai, et al., 2003b.

[8] This is for total aggregate O&M and construction costs of canal in India based in 1993 constant price. The average exchange rate in 1993 was US$ 1= Indian Rs. 31.4.

not be able to pay the full supply cost of canal water when we only consider the net marginal private benefits or irrigation obtained by the farmers[9].

Table 2. Differences between total economy-wide benefits and farmers realized (direct) benefits of irrigation development in India, 1970-94.

	Returns per ha per crop season in constant US$ (1993-94)	Returns per ha per year in constant US$ (1993-94)
1. Direct benefits to farming community	$71	$137
2. Direct + indirect all benefits to society	$321	$430
3. Irrigation multiplier value	4.5	3.15
4. Farmers share of the benefits out of the total marginal benefits of irrigation.	22%	32%

Note: 1. Irrigation multiplier. In development economics literature, the secondary impacts or induced effects) of an external intervention is referred as *multiplier effects*, or induced effect of the intervention. The *multipli*er is the ratio of the total impacts of a project to the initial (or direct) impact, thereby it is usually more than one in value term for any intervention that has positive impact in the supply chain of goods and services.

2. All US$ value are estimated in the constant prices and average exchange rate of 1993 and 1994.

3. These US$ values of marginal impact of irrigation are estimated from the regression results reported in the Table 1 by extrapolating the irrigation impact at the all India level (national level). Then, scenario analysis is done by analyzing the change in marginal benefits, when one more hectare of irrigation land is added in the economy. The per annum basis returns are estimated by using the "percent of net irrigated area" in the regression equation instead of the "percentage of gross irrigated area". Details on methods on derivation of marginal benefits of factors impact in US$ term and irrigation multipliers are found in Bhattarai et al., 2003a and 2003b. IWMI research report (forth coming).

Likewise, when we extrapolated the same procedure to derive the total marginal benefits of irrigation (from per capita NSDP model in the Table 1), then an increases in one more ha of irrigated land in India in 1995 would generate an additional net domestic product of agriculture of about Rs. 3,755 per hectare/ crop season year (in 1980 level prices. This is equivalent to Rs.10, 084 in constant price of 1993-94, or US$321/ha/per crop season[10]. That means, total economy-wide benefits of irrigation is much higher than what a typical farmer can get in terms of increased crops output in a crop season (or year). Similarly, one hectare of irrigated cropland would generate an incremental benefit of US$ 430 per annum to the local economy in India, when we use the "percent of the net irrigated land instead of "percent of the gross irrigated land" in the factors impact analysis (details in Bhattarai, et al, 2003b).

[9] Of course, marginal benefits of irrigation greatly vary across the states and by the type and nature of irrigation projects.

[10] This is based on the assumption that 665 millions population of India are in rural area in 1993-94, and 1 percent increase in gross irrigated land per year in India in 1995/96 means net addition of another 1.865 M ha of irrigated land.

Two different types of irrigation multipliers are estimated, per crop season and per hectare per year basis. The irrigation multiplier value of 4.5 in the Table 2 implies that an increase of US$100/ha/crop season of GVO in the irrigated area would generate another US$350 of indirect benefits (or secondary benefits) in the local economy. This includes increases in other allied agricultural sector activities and other rural based agro-services and marketing activities in the states. Likewise, irrigation multiplier value of 3.15 (annual basis of return) means that out of every US$100/ha/year produced in the irrigated land as a direct benefit (GVO), and additional indirect benefits of US$215/ha/year of outputs is obtained in the regional economy. Thus only 32 percent of the total benefits of irrigation is actually obtained by the typical farmer in India and the rest of irrigation benefits spill over to the regional economy. Interestingly, Tollefson (1996) has also earlier reported that only 15 to 20 percentages of the total benefits of irrigation in Alberta region of Canada have gone to the farmers, and the rest are obtained by the wider regional economy of Alberta.

6 CONCLUSION AND POLICY IMPLICATIONS

Two key factors, improved access to irrigation and improve access to rural education, have contributed largely for the recent productivity and rural income growth in India. Likewise, other factors such as, HYV adoption, fertilizers use (proxy for farming intensification) and rural road density all have significantly contributed, but their impacts are relatively lower.

The total impacts of irrigation (direct and indirect) to the regional economy (NSDP) are much larger than the farmers' share in terms of increased land productivity (GVO). We have found that only 32 percent of the total economy-wide benefits of irrigation per annum is actually realized by the typical Indian farmer. The rest of irrigation benefits (68 percent) spills over to the regional economy in terms of increased non –farm sector activities. The present literature on cost recovery in irrigation implicitly assumes that farmers are the only beneficiaries of irrigation services and the cost should be recovered from them. But, our aggregate level irrigation impact assessment in India here suggests that regional economy would get much larger share of irrigation benefits, in terms of induced effects or secondary benefits, than what the farmers (water users) get in terms of increased crop productivity. Then, the related question here is, how should we design an effective cost-recovery plan that take into account the total impact of irrigation and the scale of multiplier of irrigation development?

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