Direct and Total Benefits of Irrigation in India and its Implications to Irrigation Financing and Cost Recovery

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Poster paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

Note: The research was carried out when the first author was attached with IWMI, Sri Lanka.

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Abstract

Who benefits from irrigation development in an economy and who should pay for the cost? This question so far has not been well addressed in the irrigation literature. To answer this question we need to know, in addition to the information on farmers' level benefits (increased crop productivity), the magnitude of the total economy wide *benefits* derived by the farm and non-farm sector in the economy from irrigation development. In this study, taking an example from India, we have estimated the marginal benefits of irrigation, both *direct* (farm level benefits) and *total* (rural economy wide). Then we compute irrigation multiplier values in India, which range from 3 to 4.5. This suggests that two thirds or more of the benefits from irrigation development have actually been accrued to the non-farm sector in the economy, a factor which should be considered in developing a rational cost recovery and irrigation financing policy.

The literature on irrigation financing and cost recovery are very farmers' centric, and they neglect the economy wide benefits and the semi-public good characteristics of irrigation infrastructure systems. But, the empirical information on distributional implications of irrigation impacts derived here suggest otherwise. Hence, the study findings on irrigation multiplier value, as derived here, have large implications for irrigation financing policies, and setting broader scale of rural development public policies such as poverty alleviation and food security in the tropics where the rural livelihoods still largely rely on the productivity of irrigated agriculture and the performance of the irrigation systems.

Key words: *Direct and Indirect impacts of irrigation; Irrigation multipliers; Cost recovery and financing; Irrigation policies; Panel data analysis; India*.

JEL CODES: O130; Q 010; Q 180

1. Introduction

Irrigation represents the largest investment in the agricultural and rural development sectors in developing countries (World Bank, 2003). 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, in many developing countries, annual investment in irrigation is a major component out of the total spending in rural development sector. Yet given the magnitude of these investments there is a lack of research on the total impacts (benefits) of irrigation versus direct impacts (Dhawan, 1999). Thereby, taking an aggregate scale assessment from India, this study compares total benefits of to the economy versus the benefits of irrigation accrued to the farming sector. Then, its implications on irrigation financing are discussed.

Total benefits of irrigation include both direct benefits (accrued to the farming community), and indirect benefits (accrued to the wider sectors of the economy). The *indirect* benefits[1] of irrigation include backward linkage effects of irrigation because of additional inputs (labor and other material inputs) used in the irrigated agriculture due to improved crops productivity possible by better access to irrigation. Indirect effects of irrigation are due to income and employment effects in the agro-industry sector, and non-farm sector of the rural economy. The indirect benefits of irrigation spread to the region as a whole (sub-national scale) such as increase in direct agriculture production as well as allied agricultural sector activities, and increase in other rural based agro-services and marketing activities in the economy (agrarian economy). Therefore, the indirect benefit of irrigation plays a larger role for poverty alleviation and maintaining food security than the direct benefit in term of increased crop productivity.

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[1] *Indirect effects (benefits)* of irrigation result from backwards linkages in the agrarian economy; when the farm producing agricultural commodity purchase additional inputs from other sectors of the economy (see Mellor, 1976). The direct benefits of irrigation are measured in term of improved agricultural (crop) productivity, increased farm income, and so on. Then, the total benefit of irrigation is sum of the both direct and indirect benefits.

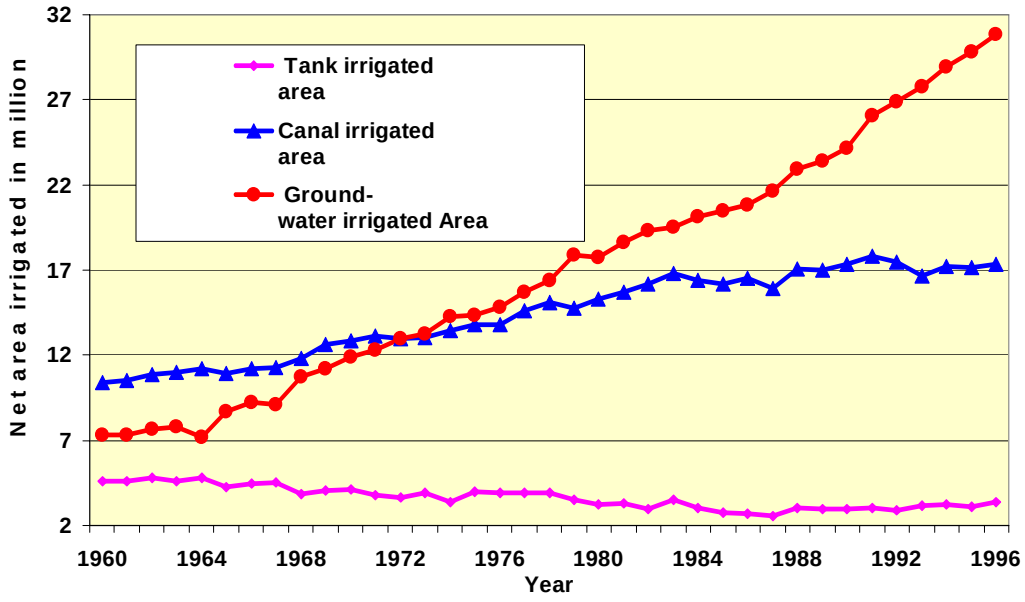
1.1 Research problem

In the context of changing roles and function of agriculture in the economy, it is increasingly being contemplated that indirect benefits of irrigation could be higher than that of direct benefits, but very few empirical case studies so far are conducted on this topic to illustrate these issues. All most all of the literature on irrigation financing and cost recovery are very farmers centric and they take into account only of the direct benefits of irrigation (see, Dhawan, 1999). In fact, designing irrigation financing and cost recovery policies only based on the direct benefits, as practiced until now without any consideration of total benefits of irrigation in the economy, often lead to sub-optimal (inefficient) irrigation financing policies.

In the irrigation literature, the rural economy wide impacts of irrigation has not been analyzed much, and even few studies that are so far available on this topic are mostly from the developed countries, with almost none from the developing countries (Powell, et al., 1985; and Mellor, 2001). Therefore, despite of huge scale of public investment in irrigation in developing countries, the total economy wide economic impacts of irrigation, and its distributional implications in those economies are still poorly understood in the literature.

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 used in irrigated agriculture and in what proportion. The irrigation impact studies have so far mainly focused on the direct impacts of irrigation with inadequate focus on the total impacts of irrigation in the economy. This study analyses this issue taking an aggregate scale of assessment in India. The level of irrigation development and a major change in irrigation structure (by irrigation types) are illustrated in Figure 1 below.

Figure 1. Changes in Structure of Irrigation in India, 1990-1996



1.2 Objectives and scope of the study

The major purpose of this study is to assess the scale of direct economic benefits and total economy wide economic benefits (impacts) of irrigation development in India.

<u>The specific objectives of the study are</u>:

a. to analyze marginal benefits of irrigation development to the local farm community and to the agrarian economy of India in general;

b. to quantify and analyze aggregate "irrigation multiplier" operating in Indian economy and discuss its implications to irrigation planning; and

c. to discuss policy implications of the "irrigation multipliers" to the cost recovery and financing issues in irrigation.

Scope of analysis

The focus of this study is on empirical evaluation of scale of distributional implications of irrigation development in India. Taking a state (province) as a unit of analysis, this study uses annual state level secondary data across 14 states of India from 1970 to 1994. These 14 states account for over 90 % of the total agrarian economy of India. The empirical analyses in this study are done at the aggregate scale by deriving the farmers' benefits as well the total benefits of irrigation in the Indian economy.

2. Literature[2]

In the water sector literature, the current discussions on irrigation financing and cost recovery are very farmer-centric and they mostly deal with *direct benefits,* that is, the benefits realized by the farmers (see WB, 2003; ADB, 2001; Small and Caruthers, 1991). There is a widely held belief among the water sector policy experts that farmers have been the major beneficiaries of irrigation investment in the past, and the irrigation cost needs to be recovered from farming sector. 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 cost-recovery policies in irrigation? Policy documents of development bank (see WB, 1993, 2003; and ADB 2001) and global declarations in water resources in relation to irrigation (World Water forums declarations 2nd and 3rd meeting; EU framework on water sector) are almost silent on the nature and scale of total *economic benefits* (direct and indirect benefits)[3] of irrigation and their implications in designing efficient and effective irrigation financing policies.

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[2] Detailed discussions on related literature on direct and total impact of irrigation can be found in the authors' another paper, Bhattarai, et al., forth coming.

[3] In fact, Bosworth, et al. (2002) study, a global scale review of water charges in irrigation, has also reported a missing link of social good and public good aspect of water in the irrigation literature.

Unless we know the scale of direct and indirect benefits of irrigation in an economy, the discussion on cost recovery and financing in irrigation will be incomplete. Understanding the scale of indirect effects of irrigation in the economy is particularly important now when the major beneficiaries of irrigation are consumers and not the farming sector alone as the case few decades ago. Moreover, even to increasing the economic efficiency of the system per se, farmer-centric irrigation cost recovery policies would be inappropriate.

For example, the rapid expansion of irrigation and widespread adoption of *green revolution* technology in Asia have resulted in a drop in world cereal grain prices by more than 50 percent from their 1970 levels (Barker and Molle, 2004). As a consequence, food grain consumers, particularly the poor for whom cereal grains are the major source of calories, might have realized most of the benefits of increased crops production. Likewise, numerous case studies have illustrated that the irrigation substantially improve the rural employment level and rural poverty in a region (Chamber, 1987; Mellor, 2001; and Hussain 2005). But, the farmers alone do not get benefits out of the employment creation and poverty alleviation in a region, but the society as such. In fact, employment creation and poverty alleviation and development of a region (country) are some of the major societal objectives, which we are trying to meet through the irrigation development. Then, the most critical question here is how one should separate the farmers' share of benefits of irrigation (i.e., direct benefits) from that of the total regional or economy wide benefits (indirect benefits) irrigation development. These indirect benefits of irrigation not direct interest of, and also not in an incentive compatible (in terms of enforcement and exclusivity of the benefits), so they are also called as semi public characteristics of irrigation (for details, see, Bhattarai, et al., forthcoming).

In case of semi-public good like irrigation, for maintaining overall economy-wide efficiency of the investment in irrigation, it is important that both the direct water users (or direct beneficiary) as well indirect water users (indirect beneficiaries) should bear the full cost of service provision, and not only the direct beneficiaries as frequently cited in the literature. In reality, farmers get only about 1/5th to 1/4th of the total economy-wide benefits of irrigation (see, Powell, et al., 1985). In this context, the farmers' centric view on cost recovery and financing in irrigation will bring a sub-optimality in irrigation financing policies. But, so far very limited empirical evidences[4] are available on what proportionate of irrigation produced benefits is actually realized by the farmers and what proportionate accrued to the regional economy, particularly in the context of the developing countries. The empirical analysis in this paper explores these issues in details talking an aggregate scale of assessment in India.

3. Methodology

This study estimate total and direct benefits of irrigation separately, and it is done by controlling the impact of other key factors on the agricultural income. Direct benefit of irrigation is measured by estimating the marginal changes in gross value of crop output per hectare (GVO), which includes 41 major crops grown in India. The *total* benefit is measured by quantifying the marginal change in agricultural sector GDP per capita of rural population (or Net State Domestic Product of Agriculture, NSDP per capita). The variable NSDP includes crops as well as livestock, other agricultural employment and value added in the agrarian economy. Then the value of irrigation multiplier is derived by estimating ratio of total impacts of irrigation in the economy to direct impacts accrued to the farming community.

[4] Sampath (1983) study theoretically derives the factors, demand and supply parameters of agricultural commodities, affecting the level of distribution of irrigation between producers and consumers in the economy. Nevertheless, Sampath (1983) study does not provide empirical evidence on the actual scale of distribution of irrigation benefits in the reality.

3.1 Marginal impact of irrigation and other factors: direct and indirect benefits

A typical supply function type of reduced-form of empirical model is used to analyze the irrigation impacts, as 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; it range from 1 to 14 (i..e, 14 states are used)

t = year; 1970 =1 and 1994 =25 in each state;

α_i = intercept term for state i; $\beta_{1 \ldots\ldots 6}$ = coefficients to be estimated (marginal effects).

<u>Dependent variables:</u>

Ag. Perf $_{it}$ = Agricultural performance indicators. Two variables are used, each separately for deriving direct and indirect impacts, they are:

(i) Per Capita Net State Domestic Product of Agril. (NSDP) (in Rs/person/year);

(ii) Per ha Gross Value of Crop Outputs (GVO), in constant price Rs/ha/ year.

<u>Explanatory variables:</u>

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

(i) % of gross irrigated crop area. This is derived as ratio of Gross Irrigated Aria (GIA) to Gross Crop Area (GCA), (in %), and

(ii) % of groundwater irrigated area. This is derived as percent of net groundwater irrigated area out of net irrigated area (unit in %);

F_{it} = Fertilizer uses per crop area (unit 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 in the variation of dependent variable; T =.1 for 1970 and T = 25 for 1994.

Dependent and explanatory variables in eq.1 were used at state level (for 14 states) and by years (1970 to 1994). Eq. 1 is estimated as a fixed effect type of Panel model. The two dependent variables are separately used one at a time. The coefficients (β_1 to β_5) of the NSDP model provide information on marginal effects on total agriculture sector (total impacts) of the input factors, whereas the coefficients ($\beta_{1.to.}$ β_5) of the GVO model provide information on the marginal effects of the input factors accrued to the farming (direct impacts). The specifications of the variables described here are detailed explained in Bhattarai, et al., forthcoming.

3.2 *Estimation of irrigation multipliers and total impacts of irrigation*

We have estimated here the "irrigation multiplier", as a ratio of marginal benefits of irrigation accrued to the regional economy (both *direct* and *indirect*) to that of the benefits realized by the farming community in term of increased crops production (*direct* benefits) by irrigation. This is done by extrapolating the marginal impact of irrigation reported in 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). The detailed explanations for estimation of irrigation multiplier are detailed explained in Bhattarai et al., forthcoming.

4. Results and Discussions

4.1. Marginal benefits of irrigation: total and direct impacts

The marginal impacts of factor-inputs on NSDP and GVO in Table 1 suggest that one percent increases in gross crop area irrigated increases per capita NSDP of agriculture by about Rs. 10.5 (or US$1.3 per capita in 1980-81 price level). Whereas, the marginal impact of irrigation on GVO model is Rs. 22/ha (at constant price of 1993/94) (or US $70/ha/year).

Considering increasing importance of groundwater in India (see Figure 1), the impact of groundwater is isolated keeping the overall irrigation effects constant across the states and over the time. The results suggest that a major portion of the benefits from the groundwater irrigation is accrued to the farming, and its marginal impact to the regional economy is negative.

Table 1. Marginal impacts of factors on agricultural sector total income (NSDP) and land productivity (GVO) in India.

Independent Variable	NSDP Model (Eq. 1)	Elasticity at Sample Mean Value	V outputs Model (Eq. 2)	Elasticity at Sample Mean Value.
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	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)	0.83		0.93	
Number of states	14		14	
Total No. of observations	350		350	

Dependent 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) across states (in Rs./ha) in constant price of 1993-94.

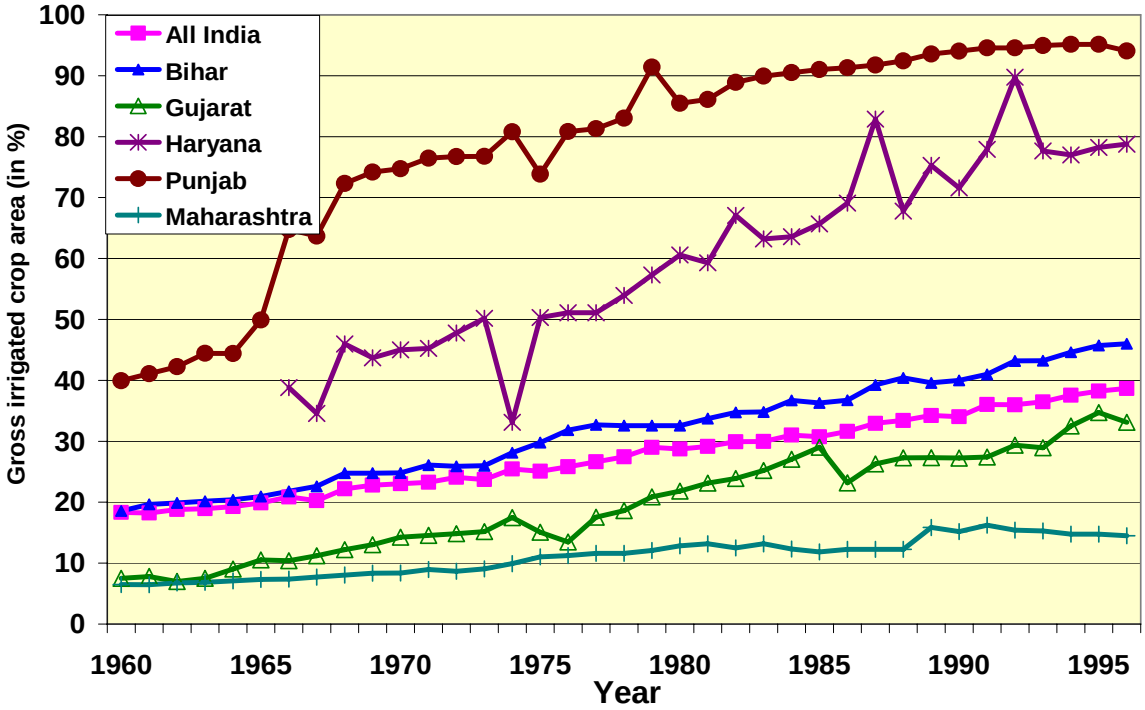
Notes: 1). Values in parentheses are absolute t-statistics; ***, ** and ** are significant at 1%, 5% and 10 % respectively.

2). Both models were estimated as fixed effects panel model using Weighted Least Squares (WLS) methods, and the results from the conversed model are reported in the table..

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

A larger impact of rural education (rural literacy rate) in both models in the Table 1 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. The sign of other variables in Table 1 are consistent with the findings from the past studies. The recent trend of irrigation development across the states (provinces) in India is illustrated in figure 2. In India, per hectare farm productivity (income) and per capita (rural capita) income from the agriculture sector are relatively high states like Punjab and Haryana where the relative access to irrigation is also far more than that of the other states of India (Fugure2). It is considered that the massive improvement in irrigation infrastructures in these two states in early 1960s, then followed by distribution of HYVs and other related supports from the government, are the main factors for the well document success story of Green Revolution in India in 1970s (Dhawan, 1999).

Figure 2. Variation on gross irrigated crop area (in %) across selected states in India,1960-96.



4.2. Comparative assessment of irrigation benefits: irrigation multipliers

In one year more than one crop is grown in a piece of land, and irrigation also positively effects livestock in addition to the crops, therefore, two different types of irrigation multipliers estimated in this study are returns per hectare per crop season and returns per hectare per year, as illustrated in Table 2. The right hand side result, with per hectare farm return per year basis, includes these elements, thereby it's value is relatively more than that of the per hectare crops return per season basis as reported in the left hand side of the Table. The methodology and analytical derivation of irrigation multipliers derived in Table 2 are summarized in a separate paper (reference, 2005).

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

	Returns per ha per crop season in constant US$ (1993-94)[a]	Returns per ha per year in constant US$ (1993-94)[b]
1. Direct benefits to farming derived from GVO model	$71	$137
2. Total benefits of irrigation (direct + indirect), derived from NSDP model.	$321	$430
3. Irrigation multiplier value	4.5	3.15
4. Farmers share out of the total marginal benefits of irrigation to the economy	22%	32%

[a] = The irrigation multiplier results reported in this column is derived from the results reported in the Table 1.
[b] = The detailed discussions on deriving multipliers here can be found in Bhattarai et al., forthcoming.

The results in Table 2 suggest that the direct benefit of irrigation to a typical Indian 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) to farming, when both the crops and livestock sectors are included. Likewise, an increases in one more ha of irrigated land in India in 1995 would generate an additional net domestic product of agriculture of about US$321/ha/per crop season (in constant price of 1993-94), as a total impacts in the economy.

The larger values of irrigation multiplier in Table 2 means that total economic impacts of irrigation in the agrarian economy is much higher than what a typical farmer can get in terms of increased crops output in a crop season (or year). In fact, 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 in the agrarian economy of India.

This means that a typical farmer would only get about 22% of the total benefits of irrigation in any crop season, and the rest of benefits accrued to the regional agrarian economy. Likewise, irrigation multiplier value of 3.15 (annual basis of return including both crops and livestock) 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, when we estimated both crops and livestock sector impacts.

5. Conclusion

In this study, we have found that two factors- improvement on irrigation and rural education (rural literacy rate), have contributed more to the recent productivity and rural income growth in India. Likewise, other factors such as, HYV adoption, fertilizers use (proxy for level of chemical and other inputs uses in farming) and rural road density all have significantly contributed, but their marginal impacts on rural income growth are relatively lower than that of rural education and irrigation.

Likewise, our analysis on annual return from irrigated agriculture shows that the irrigation multiplier operating in India ranges from 3 to 4.5, which means that only about 30 percent of the total annual benefit of irrigation is actually obtained by the typical Indian farmer and the rest of irrigation benefits (70%) spill over to the regional economy (see Table 2). The larger magnitude of irrigation impacts in per annum basis than in the case of per crop season basis of assessment is logical as the per annum basis of impact also includes livestock benefits in the economy; whereas, the return per crop season includes only returns from crop production.

The present literature on irrigation financing and cost recovery are very farmers' centric, with exclusively assuming that farmers are the major and only beneficiary of the irrigation development. In principal, the question of who benefits from the resources use is central to the issue of how costs of a project (irrigation), within an economy, should be shared among the different sectors. This paper attempts to illustrate these issues and analyses the scale of irrigation benefits received by he farers from that that of the total irrigation benefits accrued to the national economy. Therefore, the numerical information on differential impacts of irrigation in farming sector and in the regional economy wide scale, as derived in this study for India, is expected to contribute on the global debates and discussions on financing and cost recovery policies in irrigation. Some of the issues on public good aspects of irrigation and the scale of irrigation multiplier values estimated in this study are also applicable to financing policies and cost recovery issues in other related water resources projects and public investments.

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