



Improved information and understanding of the scale of incremental benefit of irrigation and other factor inputs to agricultural growth and to poverty alleviation has large public policy implications on setting rural development policy.

Analysis of data from 1970 to 1994 for fourteen major states of India shows that improvement in irrigation and rural literacy rate are the two most important factors for agricultural growth and rural poverty reduction in India.

Extending access to irrigation to a large number of farmers and investing in human capital development are crucial to increasing agricultural productivity and reducing poverty in India.

Water Policy Research

Highlight

**Impact of Irrigation
on Agricultural
Growth and Poverty
Alleviation: Macro
Level Analyses in
India**

**Madhusudan Bhattarai
A. Narayanamoorthy**

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Impact of Irrigation on Agricultural Growth and Poverty Alleviation: Macro Level Analyses in India¹

RESEARCH HIGHLIGHT BASED ON A PAPER TITLED:

“IRRIGATION IMPACT ON AGRICULTURAL GROWTH AND POVERTY ALLEVIATION: MACRO LEVEL IMPACT ANALYSES IN INDIA”

BACKGROUND

Though the positive impact of irrigation on agricultural intensification and increased crop yield has been very well documented, the marginal returns of irrigation compared to other factor inputs such as farm technology and other rural infrastructure development are still a controversial issue. Improved information and understanding of the scale of incremental benefit of irrigation and other factor inputs to agricultural growth and development and to poverty alleviation have large public policy implications on rural development policy. This is particularly more relevant in setting irrigation and agricultural investment and financing policies. This information is also important considering the recently increased global public policy priorities and thrusts on poverty reduction strategies.

In this study an attempt is made to analyse the incremental impact (input specific effects) of irrigation and other factor inputs on growth of total factor productivity and its implications on poverty alleviation in India over the last two and a half decades. Total factor productivity is also called productivity of all inputs taken together, and it is different from conventionally understood productivity measures like crops yield, water productivity, or labour productivity. In addition,

this study also examines the structure and relative importance of the factors that affect variations in poverty and rural consumption levels across India. This is done by using annual time series data from 1970 to 1994 for 14 major states of India accounting for more than 90 percent of the agrarian economy of India.

The overall growth and technical change in the agricultural sector has large implications on expanding the economic base and poverty alleviation in a region. Past empirical studies have shown that ultimately growth in productivity of all factors (TFP) in agriculture is vital for alleviating rural poverty in developing countries (Fan et al. 1999²; Mellor 2001³ and 2000; Desai 2002⁴). While summarizing the previous literature on agriculture growth and poverty reduction, Mellor (2001) points out that agricultural growth has a profound impact on poverty reduction in developing countries including reduction in inequity over time. The actual impact of agricultural growth on poverty in fact varies by the nature, region, and time period selected for the studies. Though most of the previous studies have unequivocally demonstrated that agricultural productivity growth has a positive impact on reducing poverty in Asia, the existing literature on rural poverty has failed to examine the incremental impact of each of the factor inputs on agricultural productivity growth

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² Fan S., Hazel P. and Sukhdeo T., 1999. Linkages between Government Spending, Growth, and Poverty in Rural India. Research Report No 110. International Food Policy Research Institute: Washington D.C., USA., Washington DC.

³ Mellor, J. W. 2001. Irrigation agriculture and poverty reduction: General relationships and specific needs. In Hussain I and E. Biltonen (eds), 2002. Managing water for Poor: Workshop proceeding International Water Management Institute, Colombo, Sri Lanka, August 9-10, 2001.

⁴ Desai, B. M., 2002. Policy Framework for Reorienting Agricultural Development. Presidential Address. Indian Journal of Agricultural Economics. 57 (1), 1-21.

as well as their marginal impact on poverty alleviation, and rural income enhancement (WCD 2000⁵).

Several studies in India have illustrated that irrigation management has a profound role to play in the poverty alleviation process (Chamber 1988⁶). Some of the recent aggregate level empirical studies in India have also shown that access to irrigation has a positive impact on poverty reduction (Narayanamoorthy 2001⁷; Fan *et al.* 1999; Shah and Singh 2002⁸). However, no straightforward relationship has been shown between irrigation and poverty alleviation; and the impact of irrigation on poverty alleviation depends on several other intermediate factors (Bhattarai *et al.*, 2002⁹). Thus, an improved understanding of the structure of the impact of various factors and a quantification of marginal impacts of each of the factor inputs on poverty measures is important for developing efficient and

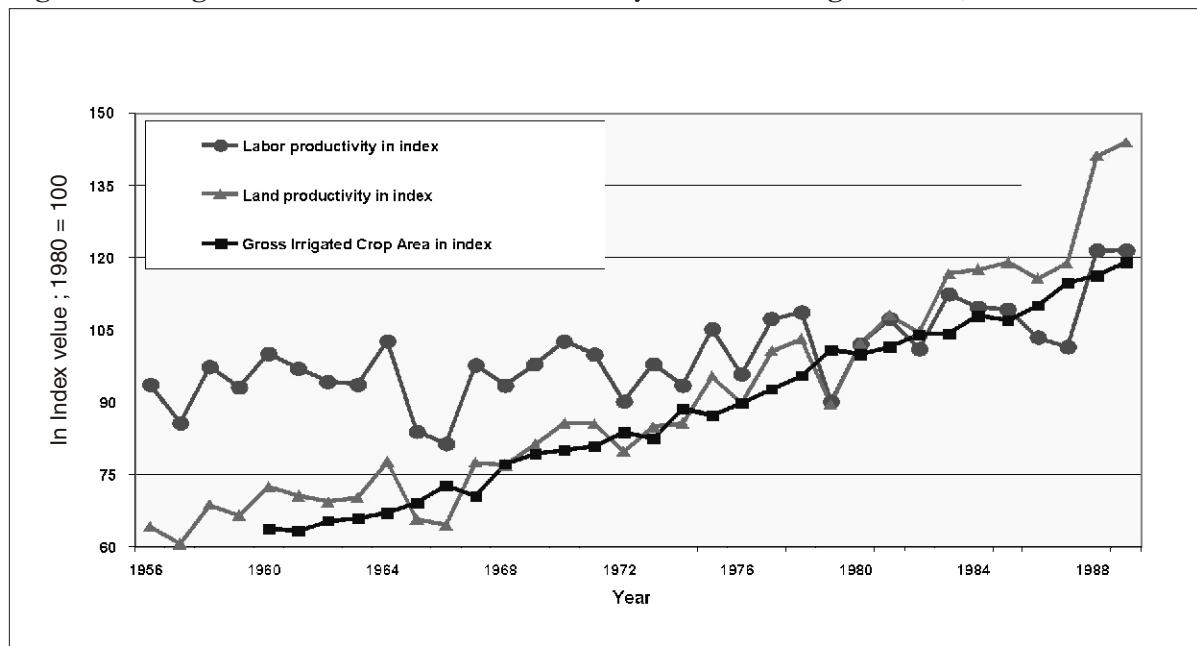
effective policy instruments for poverty alleviation.

RESULTS AND DISCUSSIONS

Factors Affecting Productivity of All Inputs

This study quantifies the marginal impact of irrigation and other factor inputs on agricultural productivity of all inputs and on two key poverty measures across the states. The empirical results (details in the full paper) show that there is no significant growth taking place in agriculture productivity when the level of all inputs use and their costs are taken together (in terms of economic and technical efficiency) over the last two decades. This productivity growth of all inputs is different from simple crop yield or labour productivity. The changing trends in irrigation and land and labor productivity are shown in Figure 1.

Figure 1: Changes in Land and Labour Productivity and Gross Irrigated Area, 1956-1989



⁵ World Commission on Dams, 2000. Dams and Development: A New Framework for Decision-Making, Earthscan Publishers, London, UK.

⁶ Chambers, Robert. 1998. Managing Canal Irrigation: Practical Analysis from South Asia. Oxford & IBH Publishing Company, New Delhi, India.

⁷ Narayanamoorthy, A., 2001. Irrigation and Rural Poverty Nexus: A State-wise Analysis. Indian Journal of Agricultural Economics. 56, 40-56.

⁸ Shah T. and O. P. Singh, 2002. Irrigation Development and Rural Poverty in Gujarat: A Disaggregate Analysis. Research Paper (in progress) of IWMI-Tata Program. International Water Management Institute: Colombo, Sri Lanka.

⁹ Bhattarai M., Sakthivadivel R., and Hussain I., 2002. Irrigation Impact on Income Inequality and Poverty Alleviation: Policy Issues and Options for Improved Management of Irrigation Systems. International Water Management Institute: Colombo, Sri Lanka

The regression results of the study show that the marginal impact of irrigation on growth of productivity of all inputs is positive and significant with an elasticity of 0.32. This means that one percent increase in irrigated area has brought about an increase of about 0.32 percent in the productivity of all inputs (TFP) in India during 1970-94. This is very high when compared to the impact of other factors such as fertilisers, HYV, and road infrastructure where the elasticity varies from 0.04 to 0.09. The marginal impact of rural literacy on agricultural productivity is the largest among the variables selected for the analysis (exactly how much is the elasticity value?). This large impact of rural education is possible considering the fact that agricultural productivity (represented by increased TFP index) and rural development are directly related to the adoption of improved technology, selection of appropriate mix of crops and inputs, timely application of these inputs, and farmers' ability to effectively process market and price information and farm managerial decisions. The impact of road

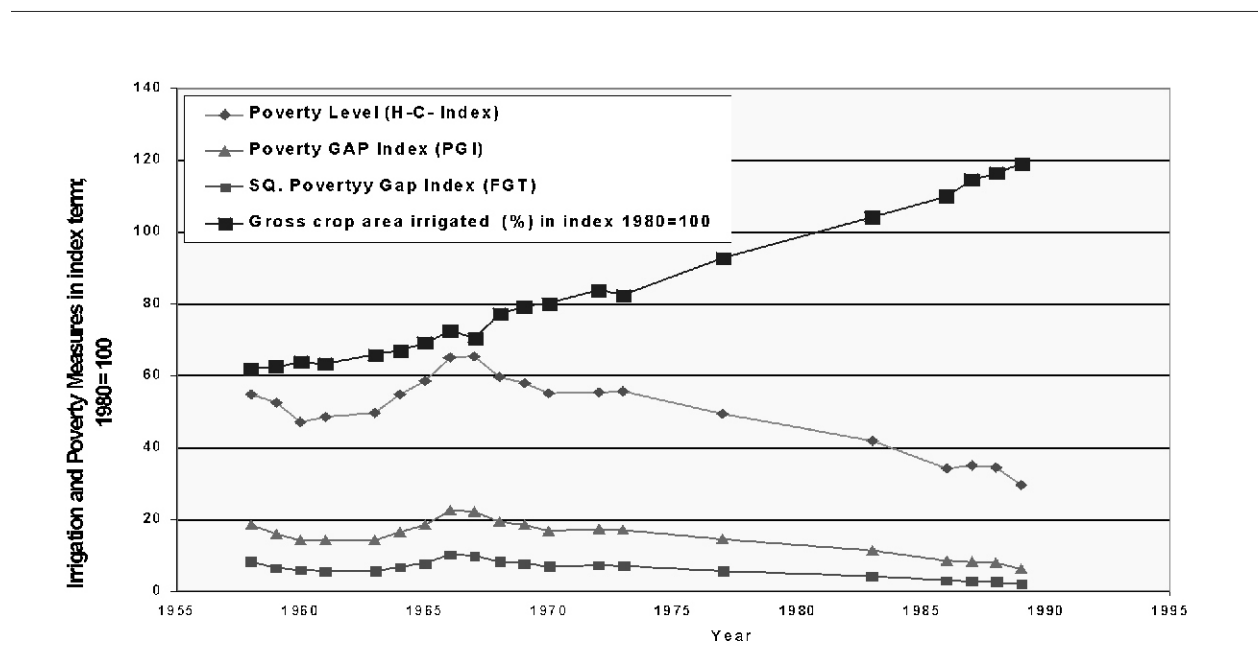
infrastructure is also positive and significant which perhaps captures the effects of market access in agricultural and rural development.

FACTORS AFFECTING POVERTY RATE AND PER CAPITA RURAL CONSUMPTION

The study has analyzed the direct impact of selected factor inputs in explaining the variation in poverty measures (poverty measure in head count ratio and rural per capita consumption) across the states for 1970-1993, using the same set of factors used in analyzing agricultural productivity. The study has found that rural poverty was unequivocally higher in a state with less extent of irrigation especially in the early 1970s. However, the relationship between rural poverty and irrigation has been decreasing in the recent past.

The change in the relationship between irrigation and poverty across the states in India over the last two decades has been shown in Figure 2. It shows

Figure 2: Relationship between in Irrigation and Poverty Measures at All India Level, 1952-1989.



that the poverty level was very high in the early 1970s, with more than 60 percent of the rural population under poverty line (head-count ratio) in India. Irrigation development was also very low at that time. However, the situation improved in the early 1990s. While analyzing the independent relationship between irrigation and rural poverty, it appears to be a strong inverse relationship between the incidence of rural poverty and percentage of gross irrigated area.

It appears to be a strong inverse relationship between incidence of rural poverty and percentage of gross area irrigated.

Besides analyzing the role of irrigation in alleviating rural poverty, we have also depicted the relationship between irrigation and poverty. The trend in variation in irrigation and the various measures of poverty and how they have changed over time is illustrated in Figure 2. The level of irrigation has more than doubled between 1960 and 1990. As can be seen from Figure 2; all the poverty measures have declined unequivocally during this period. The head count index (HCI), which measures the percentage of population below the poverty line using consumption expenditure has reduced over the last three decades. Two other measures of poverty-- poverty gap index (PGI) and Foster-Greer-Thorbecke (FGT) have declined at a faster rate.

Among all the variables selected for analyzing the poverty measures in this study, irrigation has the strongest influence in explaining the reduction in poverty. Irrigation has even a larger marginal impact on reducing the poverty than rural literacy.

The regression results analyzing the detailed structure of impact of factor inputs on variation in poverty measures (HCI) and per capita rural consumption across the states are given in Table 1. The regression results clearly demonstrate the role of irrigation in reducing rural poverty. The negative sign for time trend in poverty model (equation 1), which shows change in trend of

poverty rate over time, suggests that poverty level in India has unequivocally decreased during the time period of 1970-1993. This is also supported by the positive sign of this variable in the consumption model (equation 2) which shows the increasing rate of per capita consumption of rural population. Among all the variables selected for analyzing the poverty measures in this study, irrigation has the strongest influence in explaining the reduction in poverty. Irrigation has even a larger marginal impact on reducing poverty than the impact of rural literacy. Likewise, increased HYV adoption and fertilizers use have also played a favourable role in reducing poverty in India, but their influence on poverty reduction is lower than the marginal incremental impact of irrigation and rural literacy. Unlike productivity growth, road infrastructure does not play any positive and favourable role in explaining the variation in rural poverty in India during the time period selected for this study.

IMPLICATIONS OF THE STUDY

Despite controversies in the incremental impact analysis of factor inputs and their individual contribution to agricultural growth and rural development (WCD, 2000), this study has successfully separated the incremental marginal impact of these factor inputs in agricultural and rural development. The results demonstrate that improvement in irrigation and rural literacy rate are the two most important critical factors for the recent growth as well as the overall development of the agricultural sector in India. Considering the important role of agricultural growth on poverty reduction in the region as established by the previous literature

Improvement in irrigation and rural literacy rate are the two most important critical factors for the recent growth as well as the over all development of the agricultural sector in India. The large impact of the rural literacy rate clearly illustrates the important role of human capital development in the growth of agricultural productivity.

Table 1: Factors Determining the Variation in Poverty Measures Across 14 States of India, 1970-1994

Dependent Variable:

Eq. 1. Poverty incidence, i.e., percentage of population below poverty line by head-count ratio measure.

Eq. 2. Rural per capita monthly average consumption in Rs/person/month, 1973-74 constant prices

Independent variable	Marginal Impact (Poverty Model) Equation 1	Elasticity @ Sample Mean Value	Marginal Impact (Consumption Model) Equation 2	Elasticity at Sample Mean Value
Constant	70.87 (29.33)		43.5 (26.13)	
Time Trend	-0.50 (5.23)***		0.14 (1.94)**	
Percentage of Gross Cropped Area Under Irrigation (GIA/GCA)	-0.37 (7.95)***	0.27	0.21 (5.60)***	0.12
Fertiliser Use (kg/ha)	0.03 (0.88) ^{NS}	0.03	0.036 (1.47)	0.03
HYV Adoption Rate (percent)	-0.09 (1.62)*	0.08	0.15 (4.04)***	0.095
Rural Literacy Rate (percent)	-0.18 (1.90)*	0.12	0.18 (2.88)***	0.09
Road Density (km/1000 km ² of land)	0.005 (1.74)*	0.05	-0.01 (10.55)***	0.10
Adjusted R ²	0.53		0.35	
Number of States (Cross Section)	14		14	
Number of Data Points for each State	11		11	
Number of Observations	148		154	
Sample Mean Dependable Variable	46 percent		Rs. 63 per month	

1. Values in parentheses are absolute t-statistics; * significant at 10 percent; ** significant at 5 percent; ***- significant at 1 percent.
2. Both models in table 1 were estimated as constant intercept pooled panel model using weighted least squares technique (GLS regression). The GLS model was further iterated to minimize the mean square errors (MSE). The results are from converged models.
3. Elasticity value is estimated at the sample mean observations ($e = dy/dx \cdot x/y$). It shows percentage change in the dependent variation when the independent variable changes by one percent.
4. Poverty measures are estimated as the percentage of rural population under poverty line at any year estimated by head-count ratio (original data on poverty are adapted from Datt, 1998).
5. Rural per capita mean monthly consumption illustrates the changes in the purchasing capacity (income) of rural population at the constant prices of 1973-74. This is also another measure of change (reduction) in the poverty measure in a region.

(Evenson, *et al.*, 1998¹⁰; Fan, *et al.*, 1999; Ravallion and Datt, 1996¹¹; Mellor, 2001; Desai, 2002¹²), these two factors (irrigation and literacy rate) have obviously a larger role to play in overall rural development and poverty alleviation. The larger impact of rural literacy on interstate variations in agricultural productivity clearly illustrates the important role of human capital development in the growth of agricultural sector productivity and enhanced farm income.

The findings suggest that the future strategy of poverty reduction in rural India will largely depend on how efficiently the irrigation sector is managed

and how effectively irrigation access is provided to a large number of farmers in the regions that have still not benefited from the green revolution of the 1970s and 1980s. In addition, the lowest income quintile of population would gain more from the irrigation development than the other upper income quintiles of the population just below the poverty line due to increased employment (wage rate increase as well employment security) and other feedback effects generated in the rural economy. Thus, increasing access to irrigation is in fact a pro-poor strategy to alleviate the severity and gravity of poverty in a region.



¹⁰ Evenson, R., C. Pray, M. Rosegrant, 1999. Agricultural Research and Productivity Growth in India. Research Report No. 109. International Food Policy Research Institute: Washington D.C., USA

¹¹ Ravallion, M., G. Datt. 1995. Growth and Poverty in Rural India. Background paper for World Development Report, 1995. Policy Research Working Paper 1405. The World Bank. Washington D.C USA

¹² Desai, B. M., 2002. Policy Framework for Reorienting Agricultural Development. Presidential Address. Indian Journal of Agricultural Economics. 57 (1), 1-21.

HEADQUARTERS

127 Sunil Mawatha, Pelawatte, Battaramulla, Sri Lanka
Mailing Address : P. O. Box 2075, Colombo, Sri Lanka
Telephone : +94 1 787404,784080 ; Fax : +94 1 786854
E mail : iwmi@cgiar.org

REGIONAL OFFICE FOR ASIA

(Bangladesh, China, Nepal and Sri Lanka)
127 Sunil Mawatha, Pelawatte, Battaramulla, Sri Lanka
Mailing Address : P. O. Box 2075, Colombo, Sri Lanka
Telephone : +94 1 787404,784080,1 ; Fax : +94 1 786854
E mail : iwmi-asia@cgiar.org

CHINA

Center for Chinese Agricultural Policy,
Chinese Academy of Sciences
Building 917, Datun Road, Anwai, Beijing, 100 101, China
Telephone : +86 -10 64889440,64856535,64856837
Fax : +86 -10 64856533
E mail : j.wang@cgiar.org

NEPAL

GPO 8975 EPC 416, Kathmandu, Nepal
Telephone : +977-1 535382 (Ext. 486)
Mobile Tel : 9810 - 22573 ; Fax : +977-1 523996
E Mail : d.pant@cgiar.org

REGIONAL OFFICE FOR AFRICA

141, Cresswell Street, 0184 Silverton, Pretoria, South Africa
Mailing Address: Private Bag X813, Silverton 0127, South Africa
Telephone : +27-12 - 845 9100 ; Fax : +27-12 - 845 -9110
E Mail : iwmi-africa@cgiar.org

KENYA

C/o. ICRAF, United Nations Avenue, P. O. Box 30677, Nairobi, Kenya
Telephone : +254 - 2 - 524751,524000 ; Fax : + 254 -2 - 524001
E Mail : f.gichuki@cgiar.org

GHANA

IWMI Ghana, CSIR campus, Odeh Block,
Airport Res. Area, Accra
IWMI Ghana, PMB CT 112, Cantoments, Accra, Ghana
Telephone : +233-(0) 21-784752/53/54 ; Fax : +233-(0) 21-784752
E mail : iwmi-ghana@cgiar.org

REGIONAL OFFICE FOR INDIA

C/o. ICRISAT, Patancheru, AP 502 324, India
Telephone : +91-40 -329-6161 ; Fax : +91-40 - 324-1239
E mail : iwmi-india@cgiar.org

REGIONAL OFFICE FOR PAKISTAN, CENTRAL ASIA AND MIDDLE EAST

12KM Multan Road, Chowk Thokar Niaz Baig,
Lahore 53700, Pakistan
Telephone : +92 - 42 - 5410050-53(4 lines) ; Fax : +92-42-5410054
E mail : iwmi-pak@cgiar.org

UZBEKISTAN

Apartment NO.103, Home No.6, Murtazaeva Street,
Tashkent 700000, Uzbekistan
Telephone : +998 - 71-1370445 ; Fax : +998 -71-1370317
E mail : v.hornikova@cgiar.org

REGIONAL OFFICE FOR SOUTHEAST ASIA

(Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand, Vietnam)
P. O. Box 1025, Kasetsart University Jatujak,
Bangkok 10903, Thailand
Telephone : +66 2 561- 4433 ; Fax : +66 2 561-1230
E mail : iwmi-sea@cgiar.org

IWMI-Tata Water Policy Program

The IWMI-Tata Water Policy Program was launched in 2000 with the support of Sir Ratan Tata Trust, Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations.

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IWMI-Tata WATER POLICY PROGRAM

Elecon, Anand-Sojitra Road
Vallabh Vidyanagar, 388120, Gujarat, India
Telephone: 91-2692-229311-12-13
Fax : 91-2692-229310
E-mail: iwmi-tata@cgiar.org
Website: <http://www.iwmi.org/iwmi-tata>

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