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ROLE OF GROUNDWATER IRRIGATION ON RURAL POVERTY REDUCTION IN INDIA A MACRO LEVEL ANALYSIS

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Abstract

Role of groundwater irrigation on rural poverty is the main aim of the study. 14 major states of India were selected for the analysis. Both descriptive and regressions analysis have been used for analysis. Firstly, Multiple regressions have been used considering PRP as dependent variable and other selected poverty determinant variables as independent variables to know which of the variables play major role in reducing rural poverty. Secondly, simple regression is used treating PRP as dependable variable and groundwater irrigation as independent variable to identify the variation of irrigation on rural poverty reduction. The result of the multiple regressions shows that among the selected variables, groundwater irrigation variable pronounced significantly and predominantly in reducing rural poverty for all the points time. The outcome of the simple regression is that there is an inverse association between groundwater irrigation and rural poverty which is expected in this study.

Keywords: Groundwater Irrigation; Poverty; India; Agricultural; Rural Poverty Alleviation

INTRODUCTION

Historically, India has been depending on irrigation for agriculture purpose (Dick and Rosegrant, 2001). Irrigation increases the intensity of cultivation, crop and land productivity, land-use intensity and gross crop output per unit of land, and facilitates land augmentation which in turn increases the demand for agricultural labourers. The demand for agricultural labourers helps to increase the money wage rates and number of days of employment for agricultural labourers and then increases the total earnings of agricultural labourers. In one hand, increased income increases the purchasing power of agricultural labourers. On the other hand, intensive cultivation increases the production of agricultural commodities, in turns; the price of essential

commodities would go down. Eventually, irrigation not only helps to increase the real wage rates of agricultural labourers but also gives profits to the producers or farmers (Dhawan 1988).

While there is a positive relationship between irrigation and development process of agriculture in India (Narayanamoorthy, 2007), agriculture is the single and major factor to reduce rural poverty (Ahluwalia, 1978). Therefore, it can be demonstrated that irrigation plays major role in alleviating rural poverty too. It is also evident from most of the states of India where irrigation is high, the incidence of poverty is low and vice versa (Bhattarai and Narayanamoorthy, 2003). In one hand due to irrigation, income and purchasing power of the wage laborers increases. On the other hand, due to irrigation, increased production and productivity reduce the price of the food. Therefore, Narayanamoorthy, (2001) in his study stated that irrigation reduces rural poverty by increasing employment days and then income of agricultural laborer households and by enhancing availability of food with affordable prices.

There are mainly three types of irrigation sources namely well/groundwater irrigation, canal irrigation and tank irrigation available in India. Of which, groundwater irrigation has become a dominant source of irrigation in Indian agriculture in requisites of reliability, timely availability and controllability (Narayanamoorthy, 2007). The timely availability of groundwater irrigation helps to increase the cropping intensity, productivity and production of crops, allows the farmers to shift the cropping pattern from low-value to high-value crops, and then it increases the demand for agricultural labourers and enhances wage rates for those who mostly live below the poverty line (Vaidyanathan, 1996). The significant inverse relationship between groundwater irrigation and rural poverty is investigated by Narayanamoorthy, (2007). There are studies resulting that groundwater irrigation has increased cropping intensity, land intensity, cropping pattern, productivity, employment opportunities and income, and finally reduced rural poverty (Shah and Raju, 1988). Thus, groundwater irrigation is very crucial for the farmers as well as the agricultural labourers those are living around the groundwater irrigated areas. Studies are available with regard to groundwater irrigation and rural poverty nexus in India. A few studies have concentrated with the issue of groundwater irrigation and rural poverty reduction having taken the data up to 1993-94 across states in India. However, studies seldom available taking recent data. Keeping this in mind, this study has been taken up. The followings are the major objectives of the study.

1) To analysis the impact of groundwater irrigation in reduction of rural poverty across states in India from 1993 to 2010.

2) To investigate the variation of groundwater irrigation on rural poverty.

3) To examine the trends in groundwater irrigation development and rural poverty reduction in India.

LITERATURE REVIEW

Shah and Raju (1988) examined the empirical evidence in two similar villages selected from the west Godavari district of Andhra Pradesh and the Kheda district of Gujarat. The field work results showed that ground water markets have the potential to become powerful instruments for farmers' development and rural poverty reduction. It is also found that groundwater markets not only gives employment opportunities and income to the agricultural laborers of that areas but also helps to reduce number of poor. Similarly, Palmer and Jones (1992) argued that development of groundwater in the country has led increased agricultural growth and then reduce rural poverty. In regard to the above study, Ahmad et al., (2002) carried out a study for two growing seasons such as Kharif 2000 and Rabi 2001 in the Rechna Doab area of the Indus basin irrigation system. The empirical results of the study showed in one hand that the food-producing regions of the world have increasingly relied on irrigation from groundwater resources. And on the other hand an enhanced use of groundwater have adversely affected the sustainability of irrigated agriculture and put food security at risk. However, sustainability of irrigation and its impacts on sustainable agricultural production and poverty reduction has been obtained due to in equilibrium in groundwater recharge with tube-well extractions and capillary rise. Similarly, Bhattarai and Narayanamoorthy (2003) in their study stated that marginal impact of groundwater irrigation on poverty reduction was larger than that of canal irrigation.

Rijsberman (2003) examined the impacts of past investments on water resources development and management, irrigation and poverty reduction. By estimating the investments made by private and public in groundwater irrigation, author noted that private investment on ground water irrigation has larger impact on livelihoods for poor people than the public investments in large-scale surface water irrigation systems. Hussain et al., (2006) tried to evaluate the impact of small-scale irrigation on agricultural production and poverty in marginal areas of Punjab, Pakistan. Nine tehsils of Pothowar Plateau were selected as study area. Data were collected for the period 2002-03 and analysis was carried out with the help of various econometric techniques. The analysis revealed that the poverty head count was 44 per cent, 40 per cent and 12 per cent for small, medium and large size farmers, respectively. It established the fact that the role of small-scale irrigation in relation to poverty reduction is better than the medium and large scale irrigation. The authors suggested that an access to irrigation through small-scale irrigation schemes must be encouraged to increase crop production in order to alleviate poverty in Pothowar area. Narayanamoorthy (2007) examined the nexus between groundwater irrigation and rural poverty using state-wide cross-sectional data covering five time points: 1973-74, 1977-78, 1983, 1987-88 and 1993-94. The study showed that there is a significant inverse relationship between the availability of groundwater irrigation and the percentage of rural

poverty at all five time points. Also groundwater irrigation has become a dominant source of irrigation in Indian agriculture today. Besides increasing the cropping intensity and productivity of crops, the intensive cultivation of crops due to timely access to groundwater irrigation increases the demand for agricultural laborers and hence wages rates for those who mostly live below the poverty line. He stated that both increased affordability of foodgrain and wage rates help the rural poor to cross the poverty barriers. With respect to the above study, Gandhi and Namboodiri (2009) studied the impact of ground water irrigation. 25 states in India were selected for the study spanning from 1950-51 to 2001-02. The study estimated and brought out the result that ground water is the main source of growth in irrigated area for the past three decades, and it now covers over 60 per cent of the irrigated area in the country producing over 70 per cent of food grain from irrigated agriculture. They also found that the process of managing groundwater resource have very serious implications for the growth and development of the agriculture sector in India, as well as the alleviation of poverty in India.

Nayak (2009) in this study highlighted some aspect of inequality in distribution of land with regard to accessibility of water extraction devices which led to ground water depletion and further resulted in disproportionate use of water among different classes of land holders. The author clearly reveals that the small and marginal farmers utilize less water than their due share and pay higher prices which eventually compel them to spend more on groundwater irrigation. This brings the fact that by paying higher prices for ground water, small and marginal farmers get food insecurity.

In another study, Narayanamoorthy (2010) studied the sustainability of India's groundwater irrigation and concluded that the development of groundwater irrigation (GWI) has been very impressive in India, especially after the introduction of the green revolution. The study showed that though GWI has covered 62 per cent the net irrigated area today and provided benefits to farmers and played major role in reducing rural poverty, compared to other sources of irrigation. Addition to this, the continuous exploitation of groundwater of late has resulted in a drastic drop in the water table and led to sanitization and quality deterioration in different parts of the country. Despite the fact the groundwater has contributed overwhelmingly to agriculture growth and rural poor as well.

METHODOLOGY

The study is based on secondary data collected from 1993-94 to 2009-10 covering 14 major states in India. The dada was taken up to 2009-10 which is the latest state-wise percentage of poverty data along with other selected variables are available in India. Since the main objective of the study is to analysis nexus of groundwater irrigation and rural poverty, percentage of rural

population below the poverty (PRP) data has been collected from Planning Commission for four different time points, namely 1993-94, 1999-2000, 2004-05 and 2009-10 (Planning Commission, 2011) and groundwater irrigation area per thousand rural population (GWAPTRP) has been collected from Agricultural Statistics at a Glance (various years) and Census of India (various years). The other variables considered for the analysis are real wage rate (Rs.) of agricultural labourers (RWAL), productivity (kg) of food grains (PFG), state domestic product (Rs.) of agriculture per head of rural population (SDAPHRP), cropping intensity (CI) and food grains production (kg) per head of rural population (FPPHRP) have been collected and also estimated from the various issues of Indian Agricultural Statistics, Area and Production of Principal Crops in India (both are published by the Ministry of Agriculture, Government of India, New Delhi), Census of India and also from some of the recent published materials.

Characteristics of the Variables

Poverty is multidimensional concept. There are so many poverty determinants variables. However, only six poverty determinants variables (PFG, CI, RWAL, GWATRP, FPHRP and SDAPHRP) are selected (see Table 1). Reason behind the selection of these variables is that they would greatly influence the rural poverty (PRP) across space and time. Therefore, we have considered the variable percentage of rural poverty (PRP) as the dependent variable and percentage of groundwater irrigated area per thousand rural populations (GWATRP) has been used as irrigation variable and independent variable in the analysis. Cropping intensity (CI), defined as the ratio of gross cropped area to net cropped area in percentage term which explains how intensively crops are cultivated in a year. Other important indicators that would positively and directly influence the rural poverty are the real wage rate of agricultural labourers (RWAL), foodgrain productivity per head rural population (FPHRP) and state domestic product per head rural population (SDPPHRP) are used to study incidence of poverty.

For the analysis both descriptive and regression analysis have been carried out. Firstly, Descriptive analysis is to understand how the selected variables are related or determining rural poverty variation. Secondly, multiple regressions are used treating PRP as dependable variable and other poverty determining variables as independent variables. Following is the equation:

$$PRP = \alpha + b1\ PFG + b2\ CI + b3\ RWAL + b4\ GWAPTRP + b5\ FPPHRP + b6\ SDPPHRP \quad (1)$$

[Where, PRP= percent of rural poverty; PFG=productivity of foodgrain; CI=cropping intensity; RWAL; real wage rate of agricultural laborers; GWAPTRP; groundwater irrigation per thousand rural population; foodgrain production per head rural population; SDPPHRP=state domestic product per head rural population; b_1= regression parameter to be estimated and α =constant]

Table 1: Description of Variables Used in the Study for Analysis

Variables	Description of the variables	Unit	1993-94				2009-10			
			AVG	MIN	MAX	SD	AVG	MIN	MAX	SD
PRP	Percentage of Rural Population below Poverty Line	%	33.02	11.95	58.21	12.79	28.76	12.00	55.30	11.76
PFG	Productivity of Foodgrain	Kg/ha	1677.14	610.00	3680.00	794.86	2046.07	931.00	4144.00	923.48
CI	Cropping Intensity	%	136.70	113.65	180.90	21.39	143.11	108.10	189.40	25.89
RWAL	Real Wage Rate of Agricultural Labourers	Euro	0.214	0.136	0.365	0.080	0.339	0.160	0.826	0.167
GWATRP	Groundwater Irrigation Area Per Thousand Rural Population	Ha	53.39	3.08	160.90	42.48	67.78	6.11	183.64	49.57
FPHRP	Foodgrain Production Per Head Rural Population	Kg	369.99	48.76	1510.07	372.63	399.56	26.25	1697.29	438.87
SDAPHRP	State Domestic Product of Agriculture Per Head Rural Population	Rs	600.78	210.75	1461.76	321.64	1525.42	492.07	3668.60	812.07

Note: SD- Standard Deviation; Avg- Average; Ha- Hectare; Kg- Kilogram; MIN-Minimum; MAX-Maximum.

Sources: Computed from Census of India (various years), Office of the register General and Census Commissioner, Ministry of Home Affairs, Government of India; Agricultural Statistics in India, Government of India (various years); Agricultural Wages in India (AWI), Government of India (various years) and Agricultural Statistics at a Glance, Government of India (various years).

Thirdly, simple regression is used treating PRP as dependable variable and GWATRP as independent variables. Following is the equation:

$$PRP = \alpha + b1GWATRP \quad (2)$$

[Where, PRP= percent of rural poverty; GWATRP; groundwater irrigation per thousand rural population; b_1= regression parameter to be estimated and α =constant]

RESULTS AND DISCUSSION

According to Table 1, the average PRP is 33.02 per cent during 1993-94 and 28.76 per cent in 2009-10. This shows that there is a reduction of poverty from 1993-94 to 2009-10. The average PFG was 1677 in 1993-94 but it has increased to 2046 in 2009-10. Average of CI has increased from 136.70 per cent in 1993-94 to 143 percent during 2009-10. Similarly, average of RWAL, FPHRP and SDAPHRP were 0.214 (Euro), 369.99 (kg) and 600.78 (Rs) respectively during 1993-94 but in 2009-10, RWAL is 0.339, FPHRP is 399.56 and SDAPHRP is 1525.42. GWATRP was 53.39 during 1993-94 which has increased to 67.78 during 2009-10. While the above poverty determinant variables have increased from 1993-94 to 2009-10, PRP has decreased.

Table 2: Correlation Value: Percentage of rural Poverty with other Associated Variables

Variables	PRP	PFG	CI	RWAL	GIATRP	FPHRP	SDAPHRP
PRP	1						
PFG	-0.560[a]	1					
CI	-0.023[ns]	0.610[a]	1				
RWAL	-0.689[a]	0.538[a]	0.081[ns]	1			
GIATRP	-0.358[d]	0.676[a]	0.619[a]	0.158[ns]	1		
FPHRP	-0.389[d]	0.768[a]	0.688[a]	0.200[ns]	0.966[a]	1	
SDAPHRP	-0.601[a]	0.747[a]	0.492[a]	0.261[ns]	0.906[a]	0.909[a]	1

Notes: a, b, c and d are significant level at 1, 5, 10 and 20 percent respectively.

Sources: As in Table 2.

This show these variables might be influencing in reducing rural poverty. However, one cannot confirm that these are the variables influencing in reducing rural poverty. Therefore, we have discussed details in correlation analysis (See Table 2) that how these variables are related to poverty reduction. According to the analysis these variables (PFG, CI, RWAL, GWATRP FPHRP and SDAPHRP) are inversely related to PRP. It pointed out that the poverty determinants variables influencing rural poverty reduction. However, on the whole, one may not be able to judge decisively whether these variables play better than other factors from this descriptive analysis. Therefore, the independent relationship between poverty and other poverty

determinants variables using simple and multiple regression analysis is investigated in the following section.

Irrigation and poverty nexus

As was pointed out earlier, in order to find out the relationship between PRP and other poverty determinants variables multiple regression analysis have been used treating PRP as dependent variable and other variables as independent variable.

Table 3: Factors Determine Rural Poverty-14 States in India

Variables	Regression Results			
	1993-94	1999-00	2004-05	2009-10
PFG	-0.01[a] (-1.43)	-0.01[d] (-1.66)	-0.01[a] (-2.22)	0.00[ns] (0.43)
CI	0.39[ns] (1.38)	0.31[a] (2.96)	0.26[a] (2.86)	0.12[ns] (1.03)
RWAL	-0.27[ns] (-0.30)	-0.57[a] (-2.60)	-0.20[d] (-1.51)	-0.45[a] (-2.55)
GWATRP	-0.18[ns] (-1.15)	-0.16[a] (-2.33)	-0.07[ns] (-1.24)	-0.12[d] (1.56)
FPHRP	0.04[ns] (0.88)	0.04[a] (2.33)	0.03[a] (2.09)	0.00[ns] (0.22)
SDAPHRP	-0.04[ns] (-1.12)	-0.01[a] (-4.62)	-0.01[a] (-3.67)	-0.02[a] (-2.79)
Constant	21.33[ns] (0.58)	25.25[d] (1.84)	26.03[a] (2.10)	37.39[a] (1.99)
R^2	0.85	0.94	0.92	0.84
AR^2	0.47	0.89	0.85	0.70
DW	2.36	1.65	2.12	1.07
F	2.93	17.05	13.70	5.98

Notes: a, b, c and d are significant level at 1, 5, 10 and 20 percent respectively and ns is not significant.
Sources: As in Table 2.

The result of the regression demonstrates that among the selected variables groundwater irrigation variables is significantly and inversely influencing rural poverty. The R^2 which is estimated to be 0.85 represents that about 85 per cent of the variations in rural poverty can be explained by the variables included in the regression analysis in 1993-94 and 84 per cent in 2009-10 (See Table 3). Similarly, 94 per cent in 1999-2000 and 92 per cent in 2004-05 of the variations are explained on rural poverty. The coefficient of irrigation, which is represented by GWATRP, is negatively and significantly associated to PRP in determining rural poverty. This shows that when the irrigation increases, there is huge reduction in poverty. On the whole,

among all the variables selected for regression, irrigation is playing major roll in reducing rural poverty during periods. One percentage of increase in irrigation reduces 18 per cent of rural poverty in 1993-94. Likewise, irrigation reduces 12 per cent of rural poverty in 2009-10. Another very important variable found in the regression analysis is RWAL in influencing rural poverty. One rupee increase in real wage rate of agriculture labourers will reduce 27 per cent of rural poverty in 2009-10. Similarly, PFG, CI, FPHRP and SDAPHRP are inversely related to rural poverty. This shows that the selected variables are largely and significantly influencing rural poverty and among these variables irrigation (GWATRP) is inversely and significantly influencing rural poverty in all the eighty points of time. However, to be clear how significantly irrigation is influencing on rural poverty reduction, simple regression analysis has been used treating PRP as dependent variable and irrigation (GWATRP) as independent variable (see Table 4). The simple regression analysis shows R^2 to be 0.24 in 1993-94. This implies that groundwater irrigation makes 24 per cent of variation on rural poverty. Similarly, 24 per cent is in 1999-00, 23 per cent in 2004-05 and 05 per cent in 2009-10. The coefficient of irrigation is negative in all the eight points of time. This shows that groundwater irrigation is inversely and significantly related to rural poverty reduction for eight points of time. However, the strength of relationship between groundwater irrigation and rural poverty is decreasing.

Table 4: Impact of Groundwater Irrigation (GWATRP) on Rural Poverty

Linear Regression Results

Years	Regression Results					
	Constant	Slope	R^2	AR	F	N
1993-94	40.895 [a] (8.03)	-0.148 [a] (-1.95)	0.240	0.177	3.794	14
1999-00	30.869 [a] (5.76)	-0.149 [a] (-0.97)	0.245	0.182	3.901	14
2004-05	31.831 [a] (6.82)	-0.122 [a] (-0.94)	0.239	0.175	3.761	14
2009-10	32.609 [a] (5.92)	-0.057 [ns] (-0.86)	0.057	-0.021	0.731	14

Notes: a and ns are significant level at 1 percent and not significant respectively.

Sources: As in Table 2.

CONCLUSION

The main objective of the study is to analyse the impact of groundwater irrigation on rural poverty reduction across states in India. Therefore, 14 major states of India are selected for the analysis. Both descriptive and regressions analysis have been used to study relationship between groundwater irrigation and rural poverty. The conclusion of the study is that among the selected poverty determinants variables, groundwater irrigation is predominantly impacting on

rural poverty which is expected in this study. The strong relationship between irrigation and rural poverty is not only confirmed from descriptive analysis but also from regressions (both simple and multiple regressions) analyses. Similarly, the other selected variables (PFG, CI, RWAL, FPHRP and SDAPHRP) are also greatly associated in reducing rural poverty.

However, the strength of relationship between groundwater irrigation and rural poverty is weakening due to various reasons which have to be explored. Poverty is multidimensional concept but due to data constrains only few variables are selected along with irrigation variables. Therefore, further research works is needed to explore the other poverty determinant variables with groundwater irrigation variable. Another limitation of the study is that only 14 major states in India are selected for analysis. Therefore, it is very essential to focus on all the states in India to study the groundwater irrigation and rural poverty nexus.

In spite of research limitations, groundwater irrigation and rural poverty relationship is very strong in this study. Therefore, the policy makers, public bodies and authorities should give more importance for groundwater irrigation development that will increase the rate of alleviation of rural poverty. Also government should reduce the prices of well/tube well installation so that the small and marginal farmers will be able to install well/bore well with affordable prices. Addition to this, the government should take initiative to install public bore-wells wherever possible to support the poor and resource less farmers. This will benefit the farmers for year-round production and generate employment opportunities for agricultural labourers that help them to cross the poverty barriers.

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