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Inter-Linkages Among Agricultural Research Investment, Agricultural Productivity and Rural Poverty in India

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Inter-Linkages Among Agricultural Research Investment, Agricultural Productivity and Rural Poverty in India

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Abstract: Nearly 72 per cent of India's population and 75 per cent of the country's poor are in rural areas. A large chunk of the Indian population still depends on agriculture for its livelihood. The level of agricultural research investment has serious implications on agricultural productivity in India which, in turn, has a bearing on rural poverty. The present study attempts to analyse the inter-linkages amongst agricultural research investment, agricultural productivity and poverty at the national level. The results revealed that rural poverty was significantly and negatively influenced by the agricultural productivity at macro level. Agricultural research investment per ha and gross cropped area influenced the productivity of agricultural sector in the country positively and significantly. Therefore, the agricultural research investment in India, which accounts for less than one per cent of the GDP in agriculture, should be increased at least to one per cent if not to two per cent, as demanded by the R&D organisations in the country from time to time. Owing to positive relationship between gross cropped area and GDP in agriculture per ha, efforts should be directed towards increasing the cropping intensity mainly through crop diversification and creating irrigation infrastructure. Low agricultural productivity is the root cause of rural poverty. Hence, an effective poverty alleviation programme should aim at increasing agricultural productivity in the long run through transfer of productive assets instead of consumer goods to the farmers.

Keywords: research investment, productivity, poverty

I. INTRODUCTION

India accounts for one-sixth of the global population and is growing so fast that, probably, she will soon become the most populous nation in the world. The pressure on land is increasing day-by-day while agricultural productivity is not keeping pace with the population growth. Presently, 72 per cent of India's population and 75 per cent of the country's poor are in rural areas. Nearly two-thirds of the Indian population still depends on agriculture for its livelihood.

Growth in agricultural productivity is certainly driven by investment in agricultural research via technology development on the one hand and development of infrastructure, particularly irrigation, on the other. The government investment in agricultural research over the past decade has certainly increased in absolute terms, but

has declined relative to the size of the agricultural sector. Agricultural research investment, as a proportion of agricultural gross domestic product, was relatively low at 0.20 per cent during the 1960s, which increased to 0.43 per cent in recent years. The growth in agricultural research investment in the 1980's was dramatic, when many agricultural universities and national research institutions were set up [1]. These were the driving force behind the India's Green Revolution, which more than doubled the yields of rice and wheat within a decade.

Agricultural productivity seems to be significantly influenced by agricultural research investment and to significantly influence rural poverty in India. Though there has been a substantial increase in agricultural productivity over the last two decades, the incremental growth has been declining. The compound annual growth rate of productivity of all crops in the country was 2.56 per cent during the 1980's, which declined to 1.02 per cent during 1990's (Table-1). This has had a serious impact on the poverty level in the country.

Table 1 Compound annual growth rates of area, production and productivity of major crops in India

Crop	(Per cent)					
	1980-81 to 1989-90			1990-91 to 2000-01		
	Area	Production	Productivity	Area	Production	Productivity
Rice	0.41	3.62	3.19	0.63	1.79	1.16
Wheat	0.47	3.57	3.10	1.21	3.04	1.81
Coarse Cereals	-1.34	0.40	1.62	-1.84	0.06	1.65
Pulses	-0.09	1.52	1.61	-1.02	-0.58	0.27
Total Food grains	-0.23	2.85	2.74	-0.20	1.66	1.34
Non-Food Crops	1.12	3.77	2.31	0.84	1.86	0.59
Oilseeds	-1.51	5.20	2.43	0.44	0.66	0.61
Sugarcane	1.44	2.70	1.24	1.72	2.62	0.89
Cotton	-1.25	2.80	4.10	2.21	0.92	-1.26
All Crops	0.10	3.19	2.56	0.08	1.73	1.02

Source: GOI, 2002, Economic Survey 2001-2002, Ministry of Finance, Government of India, New Delhi.

Poverty line is drawn on the basis of expenditure that is necessary to secure the minimum acceptable living standard for work and efficiency. During 2004-05, the poverty line in our country as a whole was fixed at Rs.358.03 per month for rural areas and Rs.540.40 for urban areas (Table-2).

Table 2 State-wise Poverty Line in India (2004-05)

State	(Rs/Month)	
	Rural	Urban
Andhra Pradesh	292.95	544.30
Assam	387.64	378.38
Bihar	356.36	461.40
Gujarat	353.93	540.80
Haryana	414.76	504.20
Himachal Pradesh	394.20	504.20
Jammu and Kashmir	391.26	504.20
Karnataka	324.17	603.50
Kerala	429.07	562.90
Madhya Pradesh	324.48	569.00
Maharashtra	362.25	664.50
Orrisa	325.65	544.00
Punjab	410.38	456.10
Rajasthan	374.57	531.10
Tamil Nadu	351.86	551.70
Uttar Pradesh	369.76	487.10
West Bengal	382.82	446.10
All-India	358.03	540.40

Source: Current Affairs Year Book 2007, Chronicle Books (A Division of Chronicle Publications Pvt. Ltd.), pp.790.

Poverty has serious effects on food and nutritional security via agricultural productivity, since many farmers cannot afford to procure productivity enhancing inputs. Low agricultural research investment is also a serious threat to food security via agricultural productivity and hence poverty. In this context, the present study attempts to analyse the inter-linkages amongst agricultural research investment, agricultural productivity and poverty at the national level.

II. METHODOLOGY

The study was based on secondary data. The necessary secondary data required to achieve the first objective of the study were collected from the Directorate of Economics and Statistics, Bangalore, www.indiastat.com (website) and other statistical sources of the Government of India. The period of data availability varied for different variables considered. Since our objective was to estimate and analyse the relationships amongst agricultural research investment, agricultural productivity and rural poverty and also estimate their respective response functions, a common period of data availability, namely, 1970-95 was considered. The data thus collected were processed using tabular analysis (ratios, percentages and frequencies) and multiple linear regression models.

A. Rural Poverty Response Function at Macro Level

Rural poverty response function at macro (All India) level was initially run with several causal variables. However, agricultural productivity in terms of Gross Domestic Product in Agriculture per ha (GDPAH) turned out to be most significant. Hence, to know the magnitude, direction and strength of influence of GDPAH on rural poverty, the following linear model was used.

$$RPR_i = b_0 + b_1 GDPAH_i + u_i \quad (i=1 \dots n) \quad \dots(1)$$

Where,

RPR_i = Rural Poverty Ratio (Per cent of rural poor to total rural population)

GDPAH = Gross Domestic Product in agriculture (Rs/ha)

b₀ = Intercept

b₁ = Slope coefficient

u_i = Random disturbance term

n = Number of observations

B. Agricultural Productivity Response Function

Further, to identify the factors influencing productivity in agricultural sector at macro (All India) level, the multiple linear regression model, as specified below, was used.

$$GDPAH_i = b_0 + b_1 ARIH_i + b_2 GCA_i + b_3 GIA_i + b_4 HYVP_i + u_i \quad (i=1 \dots n) \quad \dots(2)$$

Where,

GDPAH_i = Gross Domestic Product in agriculture (Rs/ha)

ARIH_i = Agricultural research investment (Rs/ha)

GCA_i = Gross cropped area (GCA) ('000 ha)

GIA_i = Gross irrigated area (GIA) ('000 ha)

HYVP_i = Area under high yielding varieties of crops as per cent of GCA

b₀ = Intercept

b_{1...4} = Slope coefficients

u_i = Random disturbance term

n = Number of observations considered for the model

III. RESULTS AND DISCUSSION

Before actually estimating and analysing the linkages amongst agricultural research investment, agricultural productivity and rural poverty at macro (all India) level, a brief look at the status of each of these parameters in the country over time seemed useful and encouraging. Hence, the temporal status of these variables is presented under the following heads.

A. Agricultural Research Investment

The agricultural research investment rose from a mere Rs.1,581 million during 1965 to Rs.7,293 during 1995 (Table-3). The increase was not only in absolute terms but also in relative terms. The research intensity ratio, computed as proportion of agricultural research investment to gross domestic product in agriculture, also increased tremendously over the period. This ratio had always been on the rise except between 1990 and 1995 wherein there was a slight decline. During 1990s research investment was quite modest, which was worrying given their importance to national food security and poverty alleviation [2]. The increase in agricultural research investment was significant particularly after 1985. The expenditure on agricultural research has increased dramatically because during 1980's, many agricultural universities and national research institutions were set up [1].

Table 3 Agricultural research investment in India

Year	Investment (Rs.Million)	Research Intensity ratio
1965	1581	0.25
1970	1902	0.20
1975	3178	0.33
1980	3982	0.38
1985	4572	0.39
1990	7085	0.48
1995	7293	0.43

Source: Fan, 2002.

B. Gross Domestic Product in Agriculture

During 1950-95, the GDP in agriculture (at current prices) in our country has tremendously increased (Table-4).

Table 4 Gross Domestic Product in Agriculture

Year	Gross Domestic Product (Rs.Crores)			Gross Cropped Area ('000 ha)	Productivity in agriculture sector (Rs/ha)
	Agriculture	Total (All sectors)	% to Total		
a	b	c	d=(b/c)*100	e	f=(b*10 ⁷)/(e*10 ³)
1950	5117	9547	53.6	133234	384
1955	4679	10332	45.29	147311	318
1960	7158	16220	44.13	152772	469
1965	10842	25586	42.37	155276	698
1970	18352	42222	43.47	165791	1107
1975	29077	75709	38.41	171296	1697
1980	46332	130176	35.59	172630	2684
1985	76571	249547	30.68	178464	4291
1990	145734	510954	28.52	185742	7846
1995	277846	1067220	26.03	187471	14821

Source: GOI, (Several Series), National Accounts Statistics, Back Series (1950-51 to 1992-93), Central Statistical Organisation, Ministry of Statistics & Programme Implementation, Government of India.

During the same period, the GDP from all the sectors in the economy increased. However, the growth in relative terms, that is, in terms of percentage of agricultural GDP to the total GDP of the economy, had declined from 53.60 per cent to 26.03 during the selected period. In other words, the share of agriculture in the national GDP has declined significantly over the last five decades thus reaffirming negative relationship with the rate of economic development; higher the share of agriculture in the GDP, lesser the economic development and vice versa.

The agricultural productivity at national level, defined as the gross domestic product in agriculture per ha, has increased from a mere Rs.384 to Rs.14,821 during the selected period. This tremendous increase in agricultural productivity over the inflation rate could be mainly due to agricultural technology and value addition to agricultural produce through policy and infrastructural support.

C. Status of Poverty

Table-5 presents the poverty status in India since 1970 both in absolute and relative terms. It could be seen that the poverty ratio (number of poor people in an area expressed as percentage of total population in that area) declined both in rural and urban areas in the country over the years.

Table 5 Status of Poverty in India

Year	Poverty Ratio (%)		Number of Poor (million)		Share of Rural Poor in total Poor
	Rural	Urban	Rural	Urban	
1970	57.61	47.16	256.53	51.69	83.23
1975	54.44	46.10	265.48	60.79	81.37
1980	48.48	38.56	256.95	60.91	80.83
1985	42.06	34.97	242.71	65.05	78.83
1990	34.30	33.40	215.79	72.72	74.97
1995	37.15	28.40	252.15	70.54	78.14
2007*	21.10	15.10	170.50	49.60	77.46

Note: *Projected.

Source: NIRD, 2005, Rural Development Statistics 2002-03, National Institute of Rural Development, Hyderabad.

During 1970-95, the poverty ratio in rural area declined from 57.61 per cent to 37.15 per cent while in urban area, it declined from 47.16 per cent to 28.40 per cent. The rate of decline in the poverty was high in case of rural poor when compared to the urban poor. Due to high growth in agriculture, the rural poverty rate declined to 45 per cent and urban poverty also declined to 36 per cent by the mid 1980s. Whenever there is a higher growth in agricultural production and productivity, rural poverty declines; but it is also true that urban poverty falls when agricultural growth is high [2].

However, in absolute terms, the number of poor in urban area has increased from about 52 million in 1970 to 71 million in 1995. On the contrary, the number of poor people

in rural area remained almost same or even decreased (257 million in 1970 and 252 million in 1995). Another interesting feature was that the share of rural poor in the total poor (rural poverty ratio) was very high. The ratio of rural poor to urban poor was nearly 4:1 in 1970 which has declined to about 3:1 during 1995. During this period, the share of rural poor to total poor has marginally declined from 83.23 per cent to 78.14 per cent. The reduction in rural poverty during this period could be mainly due to the development of rural non-farm employment and increase in rural wages. The inter-temporal changes in the poverty ratio were more influenced by the changes in per capita consumption rather than class distribution [3]. Inter-personal inequality in the consumption distribution, measured by the Lorenz ratio, remained fairly stable for a long period but showed signs of decline recently.

D. Rural Poverty Response Function

Rural poverty response function at macro (all India) level was initially run with several causal variables. However, due to multicollinearity and autocorrelation problems some variables turned out to be insignificant and agricultural productivity in terms of Gross Domestic Product in Agriculture per ha (GDPAH) turned out to be most significant. Hence, the variable GDPAH was only retained in the model and to know the magnitude, direction and strength of influence of GDPAH on rural poverty, the linear regression model was used.

The negative relationship between agricultural productivity and rural poverty was confirmed by the estimated model. The regression coefficient was negative and significant (Table-6). As expected, the rural poverty (rural poverty ratio) was significantly and negatively influenced by the agricultural productivity (gross domestic product in agriculture per ha). The regression coefficient was significant and negative as expected. It revealed that higher the agricultural productivity, lower the rural poverty and vice versa. Since agriculture has been the main profession or livelihood of the rural masses, farm income constitutes a significant proportion of their total income. Hence, growth in agricultural productivity has increased their incomes considerably and reduced their poverty.

Table-6: Rural Poverty Response Function at Macro Level

Explanatory Variables	Notations of Coefficients	Values of Coefficients
Intercept	b_0	53.1730
GDPAH	b_1	-0.0015***
	R^2	0.65

Note: *** indicates significance at 1% probability level.
Dependent Variable=RPR [Rural Poverty Ratio]

Ghosh (1996), in his study on the incidence of rural poverty across 14 major states of India also concluded that “rural poverty is found to be inversely associated with agricultural production per head of rural population in all the time points”[4], while Narayanmoorthy (1999) confirmed a clear significant inverse relation between the incidence of rural poverty and irrigated area [5].

E. Agricultural Productivity Response Function

Further, in order to identify and estimate the major factors that governed agricultural productivity at macro (all India) level, another model was run regressing agricultural research investment per ha (ARIH), gross cropped area (GCA), gross irrigated area (GIA) and area under high yielding varieties of crops as per cent of gross cropped area (HYVP) on gross domestic product in agriculture per ha (GDPAH).

The model was a good fit as indicated by the value of R^2 (Table-7). Of all the variables included in the model, ARIH and GCA were found to influence the GDPAH positively and significantly (at 10% and 5% probability levels, respectively).

Table-7: Agricultural Productivity Response Function

Explanatory Variables	Notations of Coefficients	Values of Coefficients
Intercept	b_0	-54035.6980
ARIH	b_1	2742.3380*
GCA	b_2	0.3270**
GIA	b_3	-0.0434
HYVP	b_4	-132.2790
	R^2	0.81

Note: ** and * indicate significance at 5% and 10% probability levels.

Higher the ARIH, higher was the GDPAH and vice versa. Chandel and Paul (1999) reviewed the past contributions of agricultural research to poverty alleviation, as seen through a variety of studies, including village studies and the capacity of the Indian NARS to face the challenge of rural poverty [6]. They observed that Green Revolution technologies were effective in reducing poverty through productivity enhancement. In another study by Evenson *et al.* (1999)[1], public agricultural research and high yielding varieties accounted for nearly 40 per cent of the total factor productivity growth between 1956 and 1987. While Fan (2002)[2] observed that agricultural research investment, improved roads, irrigation, access to electricity and education contributed significantly to agricultural productivity over the sample period which in turn decreased the urban poverty.

Roy and Pal (2002) observed a decline in public investment in agriculture since the mid-1980s but an

increase in the recent past [7]. Private investment in agriculture had played a very significant role in reducing rural poverty in India. Their study inferred that subsidies were not a wasteful expenditure, but agricultural research investment was a better option than subsidizing agriculture.

In addition to substantially reducing rural poverty, Fan (2002) observed, the agricultural research investments had played a major role in the reduction of urban poverty. Agricultural research investments increased agricultural production, which in turn lowered food prices. The urban poor often benefited more from lower food prices than the non-poor since they spent a greater proportion of their income on food. Among the rural investments considered in the study, agricultural research had the largest impact on urban poverty reduction per additional unit of investment. Among all government policy instruments, increased agricultural research investment was the most effective way to reduce rural poverty.

Thus, returns to investment on agricultural research in India were very high in terms of the gross domestic product per ha, that is, productivity of the entire agricultural sector. Therefore, the agricultural research investment in India, which constitutes less than one per cent of the GDP in agriculture, should be increased at least to one per cent if not to two per cent.

Similarly, higher the GCA, higher was the GDP/HA. This was quite obvious because the annual farm income certainly increased due to increase in the number of crops grown as well as increase in the area sown more than once. Here, cropping intensity played a major role. Hence, efforts should be directed towards increasing the cropping intensity mainly through crop diversification and creating irrigation infrastructure.

IV. CONCLUSIONS

The research intensity ratio, expressed as proportion of agricultural research investment to gross domestic product in agriculture, increased tremendously during 1965-95. The share of agriculture in the national GDP has declined significantly over the last five decades (from 53.60% to 26.03%) thus indicating the rate of economic development; lower the share of agriculture in the GDP, higher the economic development. The agricultural productivity at national level, defined as the gross domestic product in agriculture per ha, has increased significantly during the selected period, owing to advancement in agricultural technology and value addition to agricultural produce through policy and infrastructural support. The poverty ratio declined both in rural and urban areas in the country over the years. The reduction in rural poverty during 1970-95

could be mainly due to the development of rural non-farm employment and increase in rural wages.

The rural poverty was significantly and negatively influenced by the agricultural productivity at macro (all India) level; higher the agricultural productivity, lower the rural poverty and vice versa. Hence, growth in agricultural productivity has increased their incomes considerably and reduced their poverty. Agricultural research investment per ha and gross cropped area influenced the gross domestic product in agriculture per ha positively and significantly.

V. POLICY IMPLICATIONS

- The agricultural research investment in India, which accounts for less than one per cent of the GDP in agriculture, should be increased at least to one per cent if not to two per cent, as demanded by the R&D organisations in the country from time to time.
- Efforts should be directed towards increasing the cropping intensity mainly through crop diversification and creating irrigation infrastructure. Even in the areas of low cropping intensity, increase in net irrigated area would enhance agricultural productivity considerably. This calls for sufficient policy support for creating irrigation infrastructure.
- Low agricultural productivity is the root cause of rural poverty. Hence, an effective poverty alleviation programme should aim at increasing agricultural productivity in the long run through transfer of productive assets instead of consumer goods to the farmers.

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