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ARTICLES

Agricultural Investments: Trends and Role in Enhancing Agricultural Output and Incomes

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ABSTRACT

Increasing agricultural productivity and sustainable food production are crucial to help alleviate hunger and requires action from governments for creating supportive rural infrastructure by enhancing public spending that is likely to invigorate private agricultural investments. The growing dependence on wage incomes poses questions on the viability of farming. The inter-linkages and complementarity between public investments, private capital formation and agricultural growth are well known. The paper examines temporal and spatial aspects of private and public agricultural and irrigation expenditure. By adopting the generalized method of moments (GMM) instrumental variable approach the paper models agriculture income as a function of spending on agriculture, irrigation and other variables for the period 2004-05 to 2018-19.

Keywords: agricultural productivity, sustainable food production, hunger alleviation, public spending, private agricultural investments

JEL: O13, Q12, Q15, Q18

I

INTRODUCTION

Increasing agricultural productivity is crucial for alleviating hunger and malnutrition. This requires governments to create supportive rural infrastructure by enhancing public spending. Recent evidence from India reveals rising immiseration of the farming community on account of land fragmentation and slowdown of incomes from agricultural sector. Wage income has overtaken income from crop production in the total household incomes and this poses questions on the viability of farming. Stagnant productivity and low product prices is largely held responsible for this. Besides sustained efforts to diversify the livelihood avenues of farmers, the focus on raising agricultural productivity to maintain viability of the farm sector cannot be sidelined.

Public intervention in agriculture through credit flows, creation of infrastructure for irrigation, marketing etc. holds considerable importance for enhancing agricultural productivity and farm incomes. Complementarity between public investments, private capital formation and agricultural growth are well documented (Bardhan *et al*., 2012, Bathla, 2014, 2017; Chand and Kumar, 2004, Alagh, 1997). Creation of public goods for the development of agriculture induces economy wide effects through the supply of materials and encourages demand for non-agricultural good and services, resulting in a virtuous cycle netting in poverty amelioration (Ahluwalia 1978, Ravallion and Datt, 1995, Fan, 2008). However, large inequities persist across states arising from variations in government spending (Chatterjee *et al*. 2022). Benefits of government transfers are appropriated disproportionately by richer agricultural households and there is need to step up capital formation in agriculturally dominant but less developed states to induce private investments by households (Bisaliah *et al*., 2013).

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Public along with private agricultural investment rose steadily till 1980-81, indicating complementarity between the two. Public spending started declining thereafter eliciting serious concerns due to its effect on fall in private investments (Bhattacharya and Rao, 1988, Mishra and Chand, 1995). The results of a multiple regression with private investment in agriculture as dependent variable showed that terms of trade for agriculture and institutional credit to the farmers had a positive impact on private capital formation during 1980-81 to 1996-97. In fact, the impact of private rather than public investment was noted to be stronger on inter-state variation in agricultural productivity (NSDP ag/ha) during this period (Chand, 2000). Following the economic reforms from 1991, public expenditure faced a downward trend manifested as a fall in area irrigated by canals. In the following period (early 2000s), the allocation for agriculture and rural employment programmes recorded an increase to combat the distress conditions in the agrarian economy. During the period 2000 to 2013, public capital formation in agriculture and input subsidies recorded an annual growth of 6 per cent, accompanied by an annual increase of 9 per cent in private investment in agriculture. The outcome of this was a high rate of growth (more than 3.5 per cent) in agriculture across the states with a rise in irrigation intensity (Bathla, 2017).

The relationship of investments with agricultural growth has been the subject of intense academic scrutiny. Fan *et al*. (2008) estimated this for the developing countries by paying attention to the role of government spending in promoting growth, along with other variables such as land, labour, fertiliser, tractor, etc. Results indicated the trend of statistical significance and positive coefficient for agricultural research variable, even though non research spending variables turned to be non-significant. Heady *et al.* (2010) using the production function approaches concluded that in developing countries policy and institutional variables including public agricultural investments with pro-agriculture price policy reforms were the significant correlates. Chand *et al*. (2012) deduced that returns to investment on agricultural R&D were a highly paying proposition under Indian conditions and further investment would generate significant returns. Bathla and Agarwal (2022) verified complementarity of public capital formation in agriculture and crowding in of private investments in the eastern Indian states. Literature clearly demonstrates that agricultural research investments have larger output-enhancing effect than other public spending. A strong extension system is crucial in disseminating knowledge resulting in productivity gains and studies have shown economically positive returns on account of increased extension expenditure (Evenson. 2001, Birthal *et al.,* 2015).

In India the correlation between agricultural growth spurred by large scale public investments and rural poverty became quite strong after the green revolution. Ahluwalia's (1978) study build a strong consensus on poverty reducing impacts of growth in rural sector triggering several other studies (e.g. Fan *et al*., 2000). The largest impact of investments on agricultural production and improved livelihoods is seen in resource poor or rain fed regions, studies therefore tend to view investment in less favoured areas as 'win-win' opportunities. Agricultural investments positively influence the urban sector as growth in agricultural and non-agricultural sectors are inter linked through product markets, labour flows and capital movement. There is growing empirical evidence to show that rural households are engaged in diversified non-farm activities that offer opportunities to spread risk across diverse livelihoods.

In rest of the paper we examine the relationship between public expenditure on agriculture and irrigation with the agricultural incomes for the period 2004-05 to 2018-19. The following section deals with temporal and spatial aspects of agricultural expenditure along with its components. Subsequent sections explain the analytical approach adopted and the results. The last section draws key policy conclusions.

II

TRENDS IN INVESTMENTS ON AGRICULTURE AND IRRIGATION

Time series data on private investment at state level is available from nationwide surveys such as All India Debt and Investment Survey (AIDIS) of NSSO for the periods 1991-92, 2002-03, 2012-13 and 2018-19. Private investment by farm households in farm business was considered for the analysis. By using the exponential growth rate, the estimates were interpolated to generate a time series on farmer's investment in agriculture. The decade of 1980s, 1990s 2000s recorded slowdown in growth in investments for farm business (agricultural activities) and a subsequent revival (Table 1). On the other hand, farmers showed a greater preference for investing in residential land and buildings. This indicates the rising trend of urbanization, industrialization and land acquisition for public purposes, in addition to land fragmentation. Such trends combine to enhance land prices that stimulate prospects for sale of land fetching larger returns to land holders than seasonal agriculture. Outlays for irrigation development, input subsidies, credit supply and favourable agricultural prices spur growth in private farm investments. This was more visible in the less developed states. By 2018-19, the state level variation in investment in farm business showed an unprecedented rise, though the long-term variation across states in non-farm private investments declined as seen through the changes in co-efficient of variation. Overall rural farm household level investment pattern shows that the significant increase witnessed in 2000s, declined again by end of 2019.

TABLE 1 : COMPOSITION OF PRIVATE FIXED CAPITAL EXPENDITURE BY RURAL HOUSEHOLDS, INDIA

	Residential land and Building	Farm Business	Non-Farm Business
(1)	(2)	(3)	(4)
1981-82	54.4	35.3	10.5
	(68.3)	(85.9)	(88.3)
1991-92	59.5	32.8	7.8
	(92.1)	(68.6)	(124.8)
2002-03	64.1	21.8	14.1
	(91.8)	(78.8)	(112.7)
2012-13	67.9	23.3	8.7
	(70.9)	(63.8)	(110.3)
2018-19	63.4	26.3	10.6
	(84.2)	(93.6)	(110.0)

Source: Calculated from AIDIS, NSSO, Various years.
Note: Figures in parentheses are the Coefficient of Variation for states.

Canal irrigation development acts as a precursor to private capital investments in terms of mechanisation and purchase of farm implements. Private investment in agriculture is influenced by several factors lead by governments' efforts in creation of surface irrigation facilities and easy access to institutional credit. Bathla (2017) for the period 1980-81 to 2013-14 showed that inadequate public capital formation during 1990's arrested farmer's spending and jeopardised technological change in agriculture. In 2000s decade acceleration in irrigation expenditure in less developed states stimulated private investment, suggesting increased budgetary outlays for poorer states and capital deepening for growth in agricultural productivity and incomes.

Analysis for public expenditure relates to the period 2004/05 to 2018/19/20 and considers seventeen major states. Public expenditure in the country is bifurcated as development and non-development expenditure and categorized further as expenditure on revenue and capital accounts. Development expenditure is categorized as social, economic and general services. Data on public investments is available from Finance Accounts of the union and the states, that provide detailed information on head- and sub-head wise capital and revenue expenditure. Yearly data on capital expenditure on agriculture sector (excluding allied sectors) and irrigation and flood control have been compiled for the last 14 years. The series has been prepared at constant (2011-12) prices by deflating the current price series with the implicit GDP deflator (WPI-overall) sourced from the Office of Economic Adviser (GOI). This series includes capital expenditure on more than 20 heads, nearly half of which are not included in the CSO series (Chand, 2000). In the empirical model discussed in later sections the value for agricultural research and development includes expenditure on crop husbandry, soil conservation that also have a research component.

We examine expenditure incurred by the state governments on agriculture and irrigation. Total public expenditure for all states grew by 14.3 per cent per annum between 1982 to 2017 in nominal terms. Development expenditure increased 14 percent annually, while non-development expenditure rose annually by 15.2 per cent. The share of development expenditure decreased from nearly 78.2 percent (1981-82) to around 72 per cent (2016-17). However, it is notable that development expenditure has outgrown population growth and per capita development expenditure increased from Rs.245.3 (1982) to Rs. 13678 (2016-17) (Finance Accounts, GOI). In constant terms the picture reveals that per capita development expenditure increased from Rs.235 (2005-06) to Rs. 7467 (2016-17). On an average for the states nearly 21 percent of the expenditure was allotted to agricultural sector followed by 14 percent to irrigation and flood control (TE 2019). The expenditure under these heads and others within the economic services nearly doubled in the post-reform period but the share of agriculture and irrigation has fallen noticeably - possibly due to dwindling capital expenditure on irrigation schemes.

State wise scenario of public expenditure on agriculture and irrigation (Table 2) reveals that public expenditure on agriculture rose from 258 billion to Rs. 694 billion between 2005 to 2017, growing at an annual rate of 11.7 per cent. This is a significant growth acceleration from 4.5 per cent annually between 1981 and 2008. In contrast, expenditure on irrigation and flood control enhanced from Rs. 405 billion to 544 billion between TE 2008 to 2017, growing at a modest rate of 3.3 per cent annually.

TABLE 2: PUBLIC EXPENDITURE ON AGRICULTURE AND IRRIGATION (RS CRORE) AND SHARE OF CAPITAL EXPENDITURE

States	Agriculture						Irrigation & Flood control						Annual Growth Rate (%)			
				Per cent capital						Per cent capital						
	Public Expenditure			formation			Public Expenditure			Formation			Agriculture		Irrigation &FC	
(1)	TE 1984 (2)	TE 2008 (3)	TE 2017 (4)	TE 1984 (5)	TE 2008 (6)	TE 2017 (7)	TE 1984 (8)	TE 2008 (9)	TE 2017 (10)	TE 1984 (11)	TE 2008 (12)	TE 2017 (13)	1981-2008 (14)	2008-2017 (15)	1981-2008 (16)	2008-2017 (17)
Andhra Pradesh	537	1420	7687	1.61	1.0	2.7	1594	10712	11028	57.17	70.9	81.7	4.1	20.6	8.3	0.3
Assam	398	551	1174	5.73	0.1	1.3	340	385	1000	74.29	39.2	59.9	1.4	8.8	0.5	11.2
Bihar	472	1027	2904	6.8	4.8	10.8	1189	1581	2245	72.82	63.5	65.5	3.3	12.2	1.2	4.0
Gujarat	402	1105	2946	24.42	7.9	15.9	1319	3262	4896	52.85	86.1	87.7	4.3	11.5	3.8	4.6
Haryana	236	650	1606	2.94	-2.4	21.5	625	1096	1247	56.4	52.0	41.0	4.3	10.6	2.4	1.4
Himachal Pradesh	258	502	908	8.61	4.4	3.1	48	268	378	58.39	54.9	43.3	2.8	6.8	7.4	3.9
J&K	203	689	1832	6.4	19.9	48.4	180	309	475	67.43	37.7	44.8	5.2	11.5	2.3	4.9
Karnataka	460	3184	6401	2.88	1.2	2.7	964	3515	5013	56.93	93.3	86.1	8.4	8.1	5.5	4.0
Kerala	337	982	3101	11.18	6.3	9.4	389	373	529	72.75	43.0	51.4	4.6	13.6	-0.2	3.9
Madhya Pradesh	1076	2557	9255	6.46	4.0	2.4	1173	2417	5128	80.17	81.7	86.9	3.7	15.4	3.1	8.7
Maharashtra	1833	3230	7656	3.44	11.2	24.1	2007	6772	5867	62.59	80.1	75.4	2.4	10.1	5.2	-1.6
Odisha	380	678	3443	11.57	7.3	3.9	779	1056	3303	84.39	72.7	71.7	2.4	19.8	1.3	13.5
Punjab	243	502	2953	--	3.0	1.6	513	829	1197	58.37	38.8	41.2	3.1	21.8	2.0	4.2
Rajasthan	264	897	2691	7.95	10.2	9.8	883	1688	1849	56.96	47.0	45.3	5.2	13.0	2.7	1.0
Tamil Nadu	788	2415	5126	12.62	39.5	10.5	420	815	1154	39.82	35.2	32.9	4.8	8.7	2.8	3.9
Uttar Pradesh	628	2749	5533	--	17.2	29.1	2286	3988	6164	53.11	53.4	48.7	6.3	8.1	2.3	5.0
West Bengal	511	871	2099	9.97	4.4	18.9	434	738	1379	37.01	29.0	61.5	2.2	10.3	2.2	7.2
All India	9038	25750	69435	6.45	11.2	10.9	15099	40540	54354	61.04	69.6	70.3	4.5	11.7	4.2	3.3

Source: Finance Accounts, GoI, various Issues

The long term growth decelerated from 4.2 per cent recorded in the earlier period. There are large variations in agricultural expenditure across the states. A higher rate of growth (nearly 20 per cent) was observed in Andhra Pradesh, Odisha and Punjab, followed by Madhya Pradesh, Rajasthan, Kerala, Gujarat and Bihar, the latter group recording annual growth above 12 per cent. In case of irrigation and flood control, states that took a lead were Assam, Odisha, West Bengal and Madhya Pradesh. Agriculture subsector showed growth acceleration in 2008-2017, over 1981-2008 period in most states. Over the three trienniums, the magnitude of expenditure on agriculture and irrigation increased noticeably in every state.

Annual growth rate for agriculture and irrigation combined accelerated from 4.3 to 7.2 per cent in 2008-2017 over 1981-2008 period. But it showed a sustained increase in the less developed, though agriculturally dependent states, pointing towards adoption of encouraging policy initiatives by the respective state governments, namely Assam, Bihar, Jammu and Kashmir, Madhya Pradesh, Odisha, Rajasthan and West Bengal, in addition to the agriculturally developed states of Punjab, Gujarat and Tamil Nadu. In contrast, the three states of Andhra Pradesh, Karnataka and Maharashtra have shown a deceleration in growth in outlays, even though these experienced an increase in the magnitude of expenditure.

While considerable increase in public expenditure on revenue and capital accounts can be observed, the capital formation (or investment) did not show a significant rise. For the states together, percentage spending on capital account, synonymous with share of capital expenditure in total agriculture increased from 6.5 per cent in TE 1984 to 11.2 per cent in TE 2008, but remained nearly unchanged in TE 2017 (Table 2). Similarly, it increased from 61 to 70 per cent in TE 2008 though in TE 2017 it did not record large change for irrigation and flood control. In the period spanning TE 2008 to TE 2017 only the states of Assam, Jammu and Kashmir, Kerala, Madhya Pradesh and West Bengal showed a significant increase in share of capital formation on irrigation. Bihar, Gujarat, Haryana, Jammu and Kashmir, Maharashtra and West Bengal doubled or more their capital spending on agriculture and allied sectors during the same period

States having a lesser share of investment indicate larger government expenditure on administrative (revenue) heads including subsidies. Despite a revival in spending from 2003-04 the capital intensity continues to be unchanged in agriculture and irrigation in nearly all the states with a few exceptions in Assam, West Bengal, Jammu and Kashmir and Maharashtra. It has been noted that the low shares of capital in development expenditure persists even at the sectoral level and its low share in total expenditure points towards inefficiency and bureaucratic apathy, especially in the larger canal irrigated systems.

The changes in composition of public expenditure on agriculture in favour of crop husbandry, food storage and warehousing, agricultural research and extension as well as major irrigation for the period 2005-17 is visible (Table 3). Expenditure pattern for TE 2017 reveals that share of crop husbandry is the largest (39 per cent) followed by storage and forestry (around 13 per cent), animal husbandry (9 per cent) and cooperation (7.6 per cent). Expenditure on plantation declined while it decelerated for dairying and cooperation.

TABLE 3: COMPOSITION OF PUBLIC EXPENDITURE ON AGRICULTURE AND PERCENT SHARE

(1)	TE 2008 (2)	TE 2017 (3)	Annual GR (2005-17) (4)
Agriculture (Rs billion)	257.5	694.35	11.65
Percent share			
Crop Husbandry	25.62	38.89	16.95
Soil & water conservation	6.21	3.64	5.22
Animal husbandry	11.13	8.73	8.67
Dairy Development	3.64	1.93	4.02
Fisheries	3.05	2.48	9.13
Forestry and wild life	19.51	13.41	7.10
Plantations	0.05	0.01	-3.92
Food, storage and warehousing	7.56	13.56	19.14
Agricultural research and education	2.42	5.53	22.39
Cooperation	15.86	7.56	2.83
Others	0.52	4.25	41.17
Irrigation (Rs. billion)	405.36	473.21	1.73
Percent share			
Major	19.37	39.57	10.14
Medium	60.87	31.18	-5.55
Major & medium	80.24	70.75	0.32
Minor	13.95	19.55	5.62
Command Area Development	1.46	1.70	3.42
Flood control & Drainage	4.35	8.01	8.89

Source: Finance Accounts, GOI, Various Years.

The share of expenditure on agricultural research and development is quite low at 5.5 per cent; resources have been diverted in a big way to the food storage and warehousing sector, the two growing at 19 to 22 per cent annually. The low share of R&D is a matter for concern given the low productivity levels and yield gaps for several crops and also as spending on R&D by private sector in the country is rather tardy. In terms of actual spending (excluding private capital) the expenditure on agriculture R&D as a per cent of agricultural GDP (TE 2019, constant price) was just 0.2 per cent varying between 0.2-0.3 per cent from 1996 onwards (Agriculture Science and Technology Indicators, IFPRI). This is less than half of the share invested by China (0.6 per cent) and considerably smaller than around 2 per cent for developed countries. Private sector continues to invest in sectors other than agricultural R&D a trend requiring rethinking as returns on investment in primary activities are better than infrastructure projects. Not only the allocation for research needs to increase but it is essential to create an enabling environment to attract private investment. Within irrigation, expenditure on major and medium irrigation occupied the largest share (80 per cent) that has reduced considerably (71 per cent) by TE 2017. Minor irrigation expenditure does show growth acceleration and contributed to around 20 per cent of spending on irrigation in TE 2017. The proportion of command area development and flood control comprised 9.7 per cent and a doubling of the share is visible from 4.4 per cent in TE 2008.

The annual growth in minor irrigation at 5.6 per cent is much higher as compared to major and medium irrigation systems (0.32 per cent). This is indicative of increasing investment in tanks, tube wells and check dams categorized as minor irrigation structures. The large gestation period involving and acquisition for dam construction and laying out of canal networks give rise to inefficiencies. The data is indicative of the fact that capital efficiency of minor irrigation systems is higher than in major and medium irrigation schemes.

Since there are considerable regional variations in public expenditure on agriculture and irrigation, an examination of the expenditure on a per hectare basis is called for (Table 4). Investment on agricultural R&D and irrigation have a direct impact on productivity levels and growth. In real terms the states show a substantial per unit change in expenditure on these heads. For the whole country the spending on agricultural R&D per hectare though miniscule showed a noticeable rise in TE 2019. That on irrigation increased two and a half times. The absolute increase per hectare for agricultural R&D was only Rs.29.5 while that for irrigation was Rs. 2661, coming to Rs. 361.5 and Rs.4422 per hectare in TE 2019, and as expected large inter-state variations in per ha spending were perceptible. States spending the maximum amount on irrigation were Andhra Pradesh and Odisha, whereas Rajasthan a largely arid state spend the least followed by West Bengal. States spending higher than the national average on irrigation were Gujarat, Himachal Pradesh, Jammu and Kashmir, Karnataka and Odisha. Punjab, a leading agricultural state is amongst the group of states with low spending along with Kerala, Assam, Bihar and Madhya Pradesh. Economic growth and development status does not seem to play a significant role

TABLE 4: EXPENDITURE ON AGRICULTURE AND IRRIGATION AND GSDP AG /HA NSA (2011-12 PRICES)

	R&D in Agriculture		Irrigation*		Private** Investment in Agri		GSDP Ag/Ha	
	TE 2008	TE 2019	TE 2008	TE 2019	2012-13	2018-19	TE 2008	TE 2019
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Andhra Pradesh	93.7	758.0	6400.6	12517.9	9103.4	16884.3	94797.7	166356.3
Assam	146.7	634.5	512.1	2351.6	3651.7	4596.8	81136.7	130420.3
Bihar	98.3	474.2	1233.2	3293.8	7584.9	11685.7	76398.3	129693.5
Gujarat	77.7	398.0	2099.4	5584.3	5075.6	3951.7	65430.7	133138.9
Haryana	181.0	584.8	1867.1	3790.8	22907.8	13187.5	103810.9	216250.6
HimachalPradesh	618.4	2387.4	2963.8	6917.9	55800.1	59072.3	192612.7	250773.6
J&K	596.9	2242.9	2209.2	4811.3	31196.1	16861.6	164127.1	206464.9
Karnataka	89.6	766.2	2168.6	7084.3	12048.0	5193.1	52795.1	85430.1
Kerala	231.9	2229.2	2170.3	2466.5	84429.4	47414.3	154580.8	215106.7
Madhya Pradesh	22.5	225.7	790.3	3234.9	4182.4	4116.9	36702.5	84283.4
Maharashtra	91.8	256.0	3406.3	4144.6	8525.5	6320.7	50239.2	102424.1
Odisha	29.8	583.0	1113.7	9723.7	5541.1	10586.0	53530.8	118091.8
Punjab	168.4	346.1	1110.7	2146.1	9526.7	7800.3	122706.4	213614.3
Rajasthan	22.0	52.7	638.8	1293.1	8642.6	5805.1	32000.7	83829.2
Tamil Nadu	166.0	629.1	962.4	3425.5	32319.2	10668.5	99778.0	244118.6
Uttar Pradesh	56.1	149.2	1342.0	3654.8	12586.0	10153.3	78583.3	129440.7
West Bengal	71.7	273.8	657.3	1644.4	19812.9	24835.9	155664.7	261542.1
India	70.0	361.5	1761.5	4422.2	11173.1	9207.6	69081.8	130491.8
CV							50.6	38.3

Source: Cols 2,3,4,5 Finance Accounts, GOI Cols 6,7- AIDIS, NSSO

Note: * Excluding drainage & flood control** Excluding expenditure on purchase of land with reference to spending on irrigation in recent past as visible in case of Kerala, Maharashtra, Punjab and Tamil Nadu where expenditure on irrigation is lower than the national average. In TE 2019 agricultural research and development expenditure was observed to be quite high in Himachal Pradesh, Jammu and Kashmir and Kerala exceeding Rs. 2000/ha. Southern states of Tamil Nadu, Karnataka, besides Assam, Odisha and Haryana also spent higher than the average expenditure per hectare of Rs. 362 per hectare. In the remaining states it hovered around the national average.

The magnitude of private investment in agriculture is considerably higher than public expenditure. States with lower average per hectare public expenditure in TE 2019 include Assam, Bihar, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. Private investments unlike public expenditure declined from an average of Rs. 11173 per hectare to Rs. 9208 per hectare over two AIDIS survey periods in real terms (2012-13 and 2018-19). However, eastern states of Bihar, Odisha and West Bengal besides Andhra Pradesh have taken significant strides. Assam, Himachal Pradesh and Madhya Pradesh did not witness major changes in per hectare private agricultural spending. In the former group of states possibly better out reach of formal financial institutions and other credit related services may have played a facilitating role. However, the situation emerging in remaining states calls out for increasing credit flows in rural areas along with robust extension services so that there is an upsurge in private investments.

Inter-state variations in income from agriculture and allied sectors are quite evident. The GSDPA per hectare for the country in the period 2006 to 2019 increased at 5 per cent annually in real terms (2011-12 prices). States witnessing higher than average agricultural growth are Gujarat, Haryana, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Tamil Nadu. States lagging behind in income per land unit are Karnataka, Madhya Pradesh and Rajasthan. What is quite noticeable is that over the period under study several agriculturally less developed states have surpassed the national average in terms of growth of output-notable examples being Madhya Pradesh, Odisha and Rajasthan. Additionally, the inter-state heterogeneity in agricultural incomes per hectare has come down with the CV declining from 51 per cent (TE 2008) to 38 per cent (TE 2019). Agricultural incomes in MP, Odisha, Rajasthan and Tamil Nadu are growing at more than 6 percent per annum during 2005 to 2019, while Gujarat, Himachal Pradesh and Maharashtra stayed close behind. However, while output from land seems to have shown an acceleration the low capital intensity of public expenditure is quite stark in most states. The only exceptions are Jammu and Kashmir, Himachal Pradesh and Kerala-states that dominantly support horticulture and other high value crops that fetch better returns per unit of sown land.

III

METHODS AND ANALYTICAL TECHNIQUE

Having examined the state level trends in investment, it is essential to ascertain the degree to which the changes in agricultural income can be attributed to public expenditure on R&D, irrigation and other avenues of government spending. We make an attempt to understand this relationship through an empirical exercise for the period 2005-06 to 2018-19 for the states of India. Expenditure on agriculture sector is the most pro-poor type of expenditure and contributes to overall economic growth. A decline in agricultural spending is likely to adversely affect poverty levels and overall economic growth of regions. Several studies at the global level have analysed the extent that government expenditure contributes to economic growth. The ordinary least square (OLS) specification for agriculture income (GSDPA) as a function of public spending on agriculture and other variables is as follows:

$$LogGSDPA/hectare = a\ log.Public\ Average\ Spending_{t-1} + \chi\ Log.Private\ Investment_{(t-1)} + \varphi logX + st + vt + \varepsilon_i \qquad \ldots.(1)$$

In the above equation gross state domestic product per hectare at time t is explained by lagged public investment in agriculture and irrigation and private investment in agriculture. X is the vector for variables such as lagged per capita non-agricultural income, rainfall condition, land available per capita etc. Land, labour availability and rainfall capture the effect of variables that influence growth of agriculture yearly. S_t and V_t in the equation represent the state fixed effects and period dummies to capture the time trend. However, since investments and non-agricultural income could also be functions of agricultural incomes there could be reverse causality. Additionally, if the lagged independent variables are correlated with the dependent variable, the OLS technique would lead to overstated coefficients. It is argued (Binswanger *et al*., 1993) that government investment itself might be allocated on the basis of agro-climatic regions with higher potential regions receiving larger investment. In contrast if targeting of resources is more for poorer area, the impact may be understated unless the endogenity problem is addressed. The introduction of state fixed effects (FE) to control for state specific and time invariant factors may still lead to bias as the residual could have a relationship with the dependent variable. The estimated coefficients of a and b may be biased if residuals are related to the independent variables. Owing to the fact that unobserved panel-level effect (fixed or random) may abound in dynamic panel-data models and the panel level effects are correlated with the lagged dependent variables, standard estimators can become inconsistent.

To tide over the endogenity problem, the generalized method of moments (GMM) instrumental variable approach is the preferred technique. An instrumental variable is one that is uncorrelated with the error term but is correlated with the explanatory variables. Arellano and Bond (1991) devised a dynamic GMM estimator (through difference equations having lagged levels as instruments) to avoid the unit root problem and address the dynamic nature of the relationship between the dependent and independent variables. The GMM approach reduces the potential endogeneity of several independent variables within the panel data. However, this technique can lead to efficiency loss during estimation, and the lagged levels are weak instruments of difference variable. Building on the work done by Arellano and Bover (1995), Blundell and Bond (1998) developed a system estimator that uses additional moment conditions, viz., lagged differences an instruments for equations in levels, in addition to lagged levels as instruments for equations in first difference.[1] The system GMM estimator is considered to have efficiency gains over the first difference GMM (Zhang and Fan, 2004) and is also designed for datasets that have several panels (cross sections) and few periods.

The moment equations using difference and system GMM technique were computed through transformation of all regressors by differencing. We examined the relationship of agricultural income (AgGSDP/Capita) in a dynamic setting with lagged investment variables as instruments along with lagged dependent variable. The following equation is estimated using the systems GMM specification:

$$\Delta\, Log\ GSDPA_t \;=\; \alpha(\Delta Log\ Public\ Expenditure\ on\ Agriculture\ _{t-1}) + \chi(\Delta Log\ Public\ Expenditure\ on\ Irrigation_{t-1}) + \phi Xt + \Delta V_i\ + \Delta E_i \quad \ldots(2)$$

Where, GDSPA is agricultural GSDP/capita, public expenditure refers to capital public investment in agriculture and irrigation (both in natural logarithms). X is the vector for private investment in agriculture per ha, per capita non-agricultural incomes, rainfall, availability of land per ha and labour (employment/ha). The α, χ and ϕ are coefficients of the explanatory variables.

IV

DISCUSSION

The regression results are presented in Tables 5 and 6. The process adopted to select the functional form is highlighted in Table 5. [2] The difference GMM estimation does not give a satisfactory fit owing to the presence of many variables compared to number of groups, hence the system GMM estimation was a better choice of functional form. The results of two different models using system GMM are given in Table 6. In the first model, we examined the first difference equation with two years lagged levels

TABLE 5: PROCESS FOR SELECTING DIFFERENCE OR SYSTEM GMM METHOD FOR DYNAMIC PANEL

Variable	Pooled OLS		Fixed Effects		Difference GMM	
Lagged Ag GSDP/capita L1	0.897	(0.03) *	0.586	(0.05) *	0.313	(0.07) *
Public Exp.Agriculture/Ha	-0.002	(0.00)	-0.002	(0.01)	-0.011	(0.01)
Public Exp. Irrigation/Ha	-0.006	(0.01)	-0.005	(0.02)	-0.017	(0.03)
Private Agri Exp./Ha	0.019	(0.02)	0.056	(0.04)	0.071	(0.04)
GSDP Non Ag/Capita	0.036	(0.02) ***	0.004	(0.06)	0.103	(0.08)
Land (GCA/Capita)	0.005	(0.01)	-1.229	(0.23) *	-1.718	(0.35) *
Labour/Ha	-0.070	(0.03) **	-1.505	(0.24) *	-2.455	(0.34) *
Rainfall	-0.001	(0.02)	0.056	(0 .03) **	0.030	(0.04)
_cons	0.609	(0.33) ***	15.343	(2.89) *	22.080	(4.11) *
Adjusted R2	0.95					
Rho			0.99			
F statistic	485.3		260.29			
Prob>F	0.0000		0.0000			
No. of observations					221	
No. of instruments					79	
Wald Chi2 Prob>chi2					2762.29	0.0000

Note: Figures in brackets are the standard errors. ***, ** and* indicate significance at the 10, 5 and 1 percent level.

As the coefficient of the lagged dependent variable for difference GMM is less than for Fixed Effects, System GMM is called for of dependent and one year lagged of independent variables as instruments and the level equations with one year lagged-dependent variable and independent variables. It can be seen that this model produces a higher estimate of the coefficient of the lagged dependent variable, supporting that the system estimator does not have a downward bias. However, the public agricultural expenditure variable was not significant. The lagged private expenditure variable and GSDP non-agriculture show a negative coefficient (not significant) as does the labour per unit of land. In the second model the system GMM estimator used first lagged differences of dependent variable as instrument for the level equation. The lagged difference of the public agricultural expenditure, public expenditure on irrigation, private expenditure on agriculture and non-agriculture GSDP/Capita were used as standard instruments for the differenced equation. Only the first lags of these exogenous variables were used. The results indicate that the dependent variable (GSDPA/Capita) is positively affected by lagged key explanatory variables (viz., public capital expenditure on agriculture/ha, public expenditure on irrigation/ha, private agriculture expenditure/ha and the non-agricultural GSDPA/capita). It may be recalled that in the pooled OLS (Table 5) amongst the investment variables, only private agriculture investments and the non-agriculture SDP/capita had a positive effect on the dependent variable. However, in system GMM the estimated coefficient for public agriculture (capital) investment (lagged) is positive (0.011) and statistically significant at 10 per cent. This includes expenditure on agricultural R &D and other subheads with R&D component. The coefficient of lagged public irrigation expenditure too is positive (0.043) and significant at 5 per cent. It indicates that 10 per cent increase in public spending on irrigation will have a lagged effect of increasing agricultural incomes by 0.4 per cent. On the other hand, lagged private investments also influence agricultural income and has a much higher elasticity at 0.14, that is significant at 1 per cent. Besides public and private investments, income is also influenced by lagged non-agricultural income, and its elasticity in raising agricultural incomes stands highest at 0.15, that is statistically significant at 1 per cent. Of course, lagged agricultural income/capita has the largest impact on raising agricultural income and the coefficient (0.65) is significant at 1 per cent.

Among the land, labour and weather conditions the most important variable emerges as the labour used per hectare (-0.54), and the relation is predictably negative. It indicates the detrimental effect on labour productivity owning to overcrowding in agriculture and the importance of diverting labour to off-farm and non-farm activities. Land availability per capita has an elasticity of 0.11 (significant at 1 per cent). Weather conditions captured through rainfall turns out to be statistically insignificant though the coefficient (0.02) is positive. It is apparent that capital investment on irrigation is far more important in raising agricultural productivity and making agriculture capable of dealing with rising vulnerabilities posed by adverse rainfall conditions and climate shocks. These results while corroborating with earlier analyses (Fan *et al.*, 2008) provide credence to the notion that agricultural incomes are positively and significantly determined by both public and private investments for agriculture along with irrigation and nonfarm incomes.

TABLE 6: ESTIMATED AGRICULTURAL GSDP FUNCTION

Dependent Variable	Log Agriculture GSDP Per Capita			
	Systems GMM (1)		Systems GMM (2)	
Independent Variables				
Lagged Ag GSDP/capita (asd)				
L1	0.667	(0.074) *	0.645	(0.034) *
L2	0.047	(0.088)		
Public Exp.Agriculture/Ha (pec)	0.01	(0.008)	-	-
Lagged	0.015	(0.007) **	0.011	(0.006) ***
Public Exp. Irrigation/Ha (pirr)	-0.06	(0.025) **	-0.065	(0.019) *
Lagged	0.044	(0.024) ***	0.043	(0.019) **
Private Agri Exp./Ha (priag)	0.543	(0.243) **	-	-
Lagged	-0.418	(0.262) ***	0.137	(0.037) *
GSDP Non Ag/Capita (nasd)	-0.167	(0.142)	-	-
Lagged	0.271	(0.141) **	0.147	(0.046) *
Land (GCA/Capita) (gca)	0.072	(0.045) ***	0.112	(0.034) *
Labour/Ha (lab)	-0.58	(0.099) *	-0.535	(0.083) *
Rainfall (rfall)	0.044	(0.031)	0.022	(0.026)
State fixed effects	Yes		Yes	
Year effects	Yes		Yes	
AR test (1) Prob > z			-2.7045	0.0068
AR test (2) Prob > z			0.32888	0.7422
Wald chi2 Prob >ch2	790619.8	0.0000	879299.7	0.0000
No. of States	17		17	
No. of Observations	204		221	
Instruments	45		99	

Note: Figures in brackets are the standard errors.
***, ** and* indicate significance at the 10, 5 and 1 per cent level.

Model 1:
Instruments for differenced equation
GMM-type: L(2/.).asd
Standard: LD.asd LD.pec D.pirr LD.pirr LD.priag LD.nasd D.gca D.lab D.rfall
Instruments for level equation
GMM-type: LD.asd

Model 2:
Instruments for differenced equation
GMM-type: L(2/3).asd
Standard: D.pec LD.pec D.pirr LD.pirr D.priag LD.priag D.nasd LD.nasd D.gca D.lab D.rfall
Instruments for level equation
GMM-type: LD.asd

To check robustness of the estimates a few diagnostic tests were conducted. The null hypothesis is rejected (at 1 per cent significance level) as seen through the Wald chi-squared test. The estimator also reports the Arellano-Bond test for serial correlation in the first differenced errors. The moment conditions are valid if there is absence of serial correlation in idiosyncratic errors. The AR tests shows that the model is not mis-specified and presents strong evidence against the null hypothesis of zeroautocorrelation in the first differenced errors at order 1 (at 1 per cent significance). Rejecting the HO at higher orders implies that the moment conditions are not valid. Further it may be noted that under System GMM the coefficient for lagged public spending on agriculture turns out to be positive and significant (elasticity of 0.015 and 0.11) as compared to OLS (-0.002) in raising agricultural incomes (Table 5). The elasticity for lagged public expenditure on irrigation also is higher at 0.04. The lagged non-agriculture GSDP shows a higher magnitude of elasticity on agricultural incomes under the system GMM specification (0.3 to 0.2) over that estimated under OLS (0.04) Under both OLS and system GMM, the coefficient for lagged dependent variable is significant and not close to one owing to difference in weather and agro-climatic conditions and variations in state level interventions. The above results reiterate the significant impact of spending on agricultural incomes, components of public spending and the role of non-agricultural incomes and private investments in raising agricultural incomes.

V

CONCLUSIONS

The analysis reiterates that agricultural spending contributed to growth in agricultural incomes, and also that the impact of capital expenditure on irrigation was more productivity enhancing. Further, private agricultural expenditure is more important than public expenditure in raising agricultural incomes. It is evident that various types of government spending have differential impacts and there is considerable scope for improving efficacy of government spending by reallocating amongst sectors. Instead of excessive spending on subsides, public resources need to be diverted to avenues that cause productivity enhancement, such as agricultural R&D, irrigation, and post-harvest facilities. Technological change and agricultural growth after the nineties received a push due to enhanced allocation of government resources for agriculture and irrigation. States that lagged in agricultural development received increased expenditure on irrigation that has in turn arrested deceleration in output growth and spurred private investments and incomes.

Given the large scale state level variations in expenditure, prioritization in terms of components of public expenditure is crucial, and requires due attention in the country’s macro level and fiscal policies. Credit supply and capital deepening through its role of facilitating private investments accelerate output growth and incomes. Agriculture led growth of rural sector is precursor to the creation of robust production and consumption linkages with the non-farm sector. Hence the role of government in providing public goods to support agriculture cannot be over emphasized. Agricultural research and its dissemination need attention of policy given the low yields for several crops and challenges posed by climate related factors. The latter necessitates adoption of suitable seed varieties. Adoption of phyto-sanitary measures are also crucial to improve India’s export potential for agricultural products. Needless to add the agenda for the government has to be broadened to include public goods that affect farmers’ welfare notably, sustainable farming, crop diversification, crop insurance, protective measures for vulnerable farmers besides the push for rural infrastructure and extension services. At the state level too efforts to adopt mechanisms for agricultural reforms are needed including enhancing budgeted capital outlays on agriculture.

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NOTES

1. The systems GMM estimator is implemented by ‘xtdpdsys’ in Stata.

2. For Difference GMM in dynamic panel data framework estimation proceeds after first-differencing the data to eliminate the fixed effects. System GMM augments Difference GMM by estimating simultaneously, in difference and levels, the two equations being distinctly instrumented (Bond 2002). As the coefficient of lagged AgGSDP/Capita (lagged dependent variable) for Difference GMM was less than for Fixed Effects, the Systems GMM was selected.

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