Chapter 2
Public Investment in Agriculture and Growth: An Analysis of Relationship in the Indian Context

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2.1 Introduction

The brunt of a cut down in public expenditure following the economic reforms from 1991 was largely borne by the agriculture, irrigation and rural development sectors. This relative '*neglect of agriculture*' in India's fiscal policy slowed down the increasing trend in area irrigated by public canals (Gulati and Bathla 2002; Chandrasekhar and Ghosh 2002). The net area irrigated by private sources of irrigation did not increase significantly. A near stagnancy in irrigation intensity coupled with recurrent droughts and high cost of inputs led to a situation of agrarian distress (Haque 2016). To arrest the situation, almost all the states in the country increased budgetary outlays towards agriculture from early 2000s along with the drought relief measures and rural employment generation programmes. Hike in minimum support price of key crops and an increased flow of institutional credit were other policy measures, primarily taken to incentivize farmers (Chand and Parappurathu 2012). A high public expenditure priority enabled public capital formation in agriculture and input subsidies to grow at an annual rate of 6% during 2000–2013. It also led to a much higher rate of growth in private investment in agriculture at almost 9% per annum in real terms (at 2004–05 prices). The irrigation intensity rose from 30 to about 50%, and agriculture was able to attain an all time high growth at 3.8% annually during this period. The most striking feature was a phenomenal rate of growth of agriculture in many laggard states between 5 and 8%.

These outcomes suggest that public expenditure is crucial for the growth of Indian agriculture and hence should be accorded appropriate fiscal space. This chapter is an attempt to empirically test this relationship based on time series data on public investment in agriculture–irrigation and gross state domestic product

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(GSDP) in agriculture and allied activities across 17 major Indian states. This analysis contributes to the literature on several aspects. First, it is carried out over a relatively longer period of time from 1981–82 to 2013–14 to cover different phases of policy reforms. Secondly, the interrelationship between public investment and agricultural growth is tested at a disaggregate level using statewise expenditures from the Finance Accounts. Given that agriculture and irrigation are state-specific subjects, such analysis has important implications for resource allocations and possible trade-off between investment and subsidy to encourage and sustain agricultural growth. Thirdly, the relationship is tested using the ordinary least squares (OLS) and is supplemented with the generalized methods of moments (GMM) technique. The GMM has an edge over OLS as it enables to control for possible endogeneity between the public expenditure variables and other explanatory variables. The technique takes instrumental variables, which are the lagged values of the regressors and hence creates a dynamic setting to capture endogeneity.

We take forward the discussion on the impact of public expenditure on agricultural growth by providing theoretical and empirical evidence, with a particular focus on India.

The rationale behind the allocation of public resources to agriculture lies in its nature of public goods. Social benefits from agricultural expenditure are far greater than the private producer benefits, and private producers cannot extract compensation for the use of agricultural spending from all consumers. Hence, the amount spent by the private sector tends to be lower than the socially optimal level, and this underprovision creates a rationale for the public provision of such goods (Fan te al. 2008). A good example of public good is agricultural research and development (R&D). The provision of such resources to agriculture and other economic sectors helps the government to implement its development and welfare goals directly by increasing capital stock and indirectly by increasing the marginal productivity of both publicly and privately supplied production factors (Armas et al. 2012). Economic theory and empirical evidence advocates that increased agricultural productivity is important in development because it frees up resources through resource reallocation and provides raw material for the development of other sectors. It also contributes to higher income and hence higher demand by rural population for inputs, goods and services produced by the spillover effects to non-agricultural sector. Given that rapid growth of productivity is the major driver of agricultural growth, the key to regional progress out of poverty is mostly through technology adoption and increased spending on R&D (Fan 2008).

In several studies on developing economies, the focus is on composition of spending patterns which may differently affect agricultural production, growth, food security and poverty reduction. Fan and Rao (2008), Fan and Brzeska (2010) and Mogues et al. (2012) reviewed the impact of various types of public expenditures on farm output and poverty in the developing countries. Government expenditure on rural development, rural infrastructure such as transport, power and irrigation along with that on health and education influence agricultural sector through multiple pathways. Rural infrastructure has direct and indirect bearing on agricultural growth and rural poverty reduction by facilitating agricultural production and productivity growth since its impact operates in a cumulative and multiple ways (Hazell and Haggablade 1991; Ravallion and Dutt 1995; Fan et al. 2008). The consensus from international comparison is that public investments are essential to achieve the dual objective of growth and poverty reduction, though each head has a differential impact[1] (Mogues et al. 2012, 2015). A good number of studies in India also corroborate these findings, i.e. the public expenditure on agriculture and rural development induces private farm investment and growth (Dhawan 1998; Gulati and Bathla 2002; Bathla 2014).

While the significance of public investments cannot be undermined, input subsidies are widely used to support agricultural production all over the world. Empirical evidence on the issue of allocation of public resources towards farm investments vs. subsidies is somewhat mixed. For example, in the Indonesian case, Armas et al. (2012) found a positive impact of public spending on agriculture and irrigation, while spending on fertilizer subsidies had an opposite effect on growth during the period 1976–2006. In India, recognizing the imbalance between subsidies and public agricultural expenditure, several studies posit that this phenomenal increase in subsidies has adversely affected public investment in agriculture and hence should be streamlined[2] (Gulati and Narayanan 2003; Mogues et al. 2012). Furthermore, the input subsidies which were considered crucial at the initial stage of Green Revolution in the 1960s and 1970s in adoption of new technologies in India showed diminishing marginal returns during the eighties and up to mid-nineties (Fan et al. 2008). The analysis for the recent period carried out by Bathla et al. (2017) from 1981–2013, however, finds fertilizer subsidy, which seems to have again assumed importance although higher marginal returns continue to be from investments in agricultural R&D, education, health, and energy.

Clearly, more research is needed on the subject regarding complete withdrawal or rationalization of subsidies in agriculture. A few studies support input subsidies in raising private investment and accelerating productivity of certain crops in certain regions, albeit imbalance in the use of NPK (Sharma 2013; Chand and Kumar 2004). Similarly, Chand and Pandey (2008) cautioned on a complete removal of fertilizer subsidy as it would lead to a 9% reduction in food grain production in India. A growing literature on the subject from the African countries favours an increased public expenditure towards subsidies as it may provide incentives to private investment under certain conditions and trigger agricultural growth (Chirwa and Dorward 2013). This might also be the case in India during the last decade

[1]Fan (2008) indicated that crop research has helped reduce large numbers of rural poor people. It is estimated that every $1 million invested at the International Rice Research Institute (IRRI) in 1999 would lead to more than 800 or 15,000 rural poor people lifted above the poverty line in China and India, respectively.

[2]A cut down in subsidies in India was also suggested to address other associated issues including inequity across states, farm size and crops, resource use inefficiency and environmental degradation from overuse of land and water resources.

when government increased the magnitude of subsidies along with investments that, along with other factors, may have triggered higher growth.

In this chapter, we quantify the relationship between public expenditure on agriculture and irrigation and agriculture income from 1981–82 to 2013–14 using a single equation model. The next section explains the analytical approaches and presents temporal and spatial trends in public expenditure (revenue and capital) on agriculture and irrigation and their composition. Section 2.3 presents empirical results, and Sect. 2.4 summarizes the findings and draws key conclusions.

2.2 The OLS and Dynamic Panel Approaches and Data

The basic OLS regression equation specifies agriculture income as a function of public investment on agriculture and other factors.

$$\begin{aligned}\text{Log GSDPA}_t = {} & \alpha \log \text{Public Agri R\&D}_{t-1} + \chi \log \text{Public Irrigation}_{t-1} \\ & + \varphi \log X + s_t + v_t + \varepsilon_t\end{aligned} \tag{2.1}$$

Where gross state domestic product agriculture per capita (GSDPA) in period t is explained by per hectare public investment in agriculture R&D and irrigation (both lagged), X is a vector of variables, viz. lagged private investment in agriculture, per capita non-agriculture income, weather conditions represented by rainfall, availability of land and labour (employment/ha). The α, χ and Φ represent the respective coefficients of the explanatory variables. Public spending on agriculture and minor–medium–major irrigation is taken separately to account for their individual effects. Input subsidy is not considered as expenditure on it is subsumed in agriculture and irrigation heads. Non-agriculture income may also capture urbanisation that promotes jobs out of agriculture, resulting in an increasing share of nonfarm activities in the income portfolio of rural households. Land, employment and rainfall represent the control variables, which are taken to influence agriculture growth in the same year. The s_t are state fixed effects, and v_t are vector of period dummies taken to capture time trends.

The OLS estimates are biased if lagged independent variables are correlated with the dependent variable, we introduce state fixed effects to control for state-specific and time invariant factors that influence agriculture GSDP. The bias may remain as the residual may have time varying and state-specific factors that influence income. If such factors are correlated with investments, then the estimated coefficients of a and b are biased. Further, the relationship between agriculture and non-agriculture income is bidirectional in India. There is a possibility of a simultaneity bias within the explanatory investment variables and the dependent variable, i.e. agriculture income. The Hausman test confirms the presence of endogeneity problem.

These biases can be addressed by estimating a system of moment equations using a difference or system GMM technique (Arellano and Bond 1991; Blundell and Bond 1998). Arellano-Bond estimation begins by transforming all the regressors, usually by differencing. The relationship is examined within a dynamic setting based on lagged levels of the variables as instruments in the first differenced equation (Roodman 2006). Investment variables specified in the equation are used as instruments with first and second lags along with first lag of GSDPA and GSDP. The following equation is estimated using first difference specification—xtabond2 command in Stata.

$$\begin{aligned}\Delta \text{Log GSDPA}_t = {} & \alpha\,(\Delta \log \text{Public R\&D}_{t-1}) + \chi \log(\Delta \text{Public Irrigation}_{t-1}) \\ & + \varphi(\Delta \log X) + \Delta v_t + \Delta \varepsilon_t\end{aligned} \tag{2.2}$$

The data base relates to 17 major states from 1981–82 to 2013–14. These include Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. Data is compiled from various sources, viz. Finance Accounts, Statistical Abstract of India, Agricultural Statistics at a Glance, Fertilizer Statistics and NSS AIDIS (schedule 18.2) for private investment (by rural farm households) in farm business. The NSSO All India Debt and Investment Survey (AIDIS) were carried out in 1981, 1991, 2002 and 2012. Using exponential rate of growth, the estimates are interpolated to generate a time series on farmers' investment. The expenditures in three newly created states, Chhattisgarh, Jharkhand and Uttaranchal, are available from 2000 onwards, and their respective parent states viz. Madhya Pradesh, Bihar and Uttar Pradesh are merged to create consistent series.

The public expenditure series, private farm expenditure (investment) and other data set are reported in nominal prices. These have been converted into real prices at 2004–05 base using GSDP deflator from EPW Research Foundation. The impact of investments on agriculture R&D and irrigation usually lasts more than one year, and we have considered capital expenditure as capital stocks using a 10% depreciation rate in the empirical model based on the existing literature (Fan 2008; Fan et al. 2008). Agriculture R&D is broadened to include expenditure on soil conservation, crop and animal husbandry as these heads do have research components. The series on capital stock is added to revenue expenditure, which is mainly incurred towards meeting day-to-day expenses and subsidies. The time series on stock plus revenue are used only in the empirical analysis. It is important to mention that the economic and functional classification in the budget and finance accounts have changed since 1987 and extra efforts have been made to adjust the expenditure data in the period 1981–1986 under various heads to match with the new budgetary classification.

2.2.1 Temporal and Spatial Trends in Public Expenditure on Agriculture and Irrigation

Public expenditure in India is broadly categorized as development and non-development expenditure, which are further bifurcated into revenue (current) and capital expenditures. Capital expenditure refers to expenditures usually borrowed for capital formation such as asset creation, machinery and construction. Expenditures on agriculture and irrigation heads are highly decentralized. Funds are routed through the central government to the respective state governments and the former also spends directly on many economic and social services. The responsibility of incurring expenditure on agriculture as well as irrigation-flood control lies squarely with the states. Within agriculture, expenditure on various flagship programs and also R&D is undertaken by the central government, but is routed through the state budgets. Only the outlays on interstate rivers and fisheries outside territorial waters, fertilizer and food subsidy are predominantly undertaken by the central government. In this study, the expenditure by the central government and loans and advances are not taken to avoid double counting.

The data shows that total public expenditure of all the states has expanded by more than 7 times from 1981/82 to 2013/14, growing at a rate of 6.7% per year. Development expenditure increased at 5.8% annually, much slower than non-development expenditure at 8.3%. As a result, the share of development expenditure declined continuously from 75% in 1980 to around 65%. It is also promising to see that development expenditure has consistently outgrown population growth, and per capita development expenditure increased from 1,513 in 1981 to Rs. 7,270 in 2013.

Expenditure on agriculture and irrigation heads fall under the economic services. It is found that on average, nearly 25% of expenditure was allocated to irrigation and flood control, followed by agriculture and allied activities at 19.2%. Although the amount spent on these heads as well as on others within the economic services has more than doubled in the post-reform period, it is alarming to notice that the share of agriculture, irrigation-flood control fell substantially. It could be due to low growth in capital expenditure (investment) for irrigation schemes. Expenditure in agriculture and allied activities also grew at a slow pace.

Table 2.1 reveals that public expenditure on agriculture has increased from Rs. 90.38 billion to Rs. 454.15 billion at an annual rate of 4.59% during 1981–2014. In contrast, irrigation and flood control expenditure has stepped up from Rs. 150.99 in TE 1984 to Rs. 477.79 billion by TE 2014, and grew at a modest 4% rate. Large variations in these expenditures are visible across the states, showing a higher rate of growth near 5% in Gujarat, Karnataka, Kerala, Madhya Pradesh, Odisha, Punjab, Rajasthan and Uttar Pradesh. In case of irrigation, Andhra Pradesh, Himachal Pradesh, Karnataka, Maharashtra and Tamil Nadu have taken a lead. It is also clear that the richer states have taken a lead in allocating more outlays including that on input subsidies.

Table 2.1 Public expenditure on agriculture and irrigation (Rs. billion) and % share of capital expenditure (2004–05 prices)

	Agriculture		% capital formation		Irrigation and flood control		% capital formation		Annual rate of growth: 1981–2014	
	TE 1984	TE 2014	TE 1984	TE 2014	TE 1984	TE 2014	TE 1984	TE 2014	Agriculture	Irrigation
Andhra Pradesh	5.37	28.45	1.61	1.34	15.94	114.71	57.17	57.29	4.56	7.11
Assam	3.98	12.11	5.73	1.33	3.40	10.88	74.29	61.81	2.08	2.59
Bihar	4.72	26.56	6.8	5.63	11.89	27.98	72.82	65.07	4.02	2.04
Gujarat	4.02	27.9	24.42	16.3	13.19	47.84	52.85	86.45	5.46	3.91
Haryana	2.36	14.38	2.94	26.14	6.25	10.99	56.4	40.58	3.6	1.98
Himachal Pr	2.58	7.98	8.61	5.02	0.48	3.35	58.39	48.59	3.28	7.45
J&K	2.03	10.31	6.4	27.04	1.80	4.60	67.43	48.96	4.88	3.68
Karnataka	4.6	48.05	2.88	2.76	9.64	34.49	56.93	88.07	7.30	4.57
Kerala	3.37	24.48	11.18	7.48	3.89	5.46	72.75	47.17	5.59	0.77
Madhya Pr	10.76	56.8	6.46	3.18	11.73	37.98	80.17	84.16	4.96	3.75
Maharashtra	18.33	54.88	3.44	17.2	20.07	66.32	62.59	73.94	3.11	4.85
Odisha	3.8	22.56	11.57	3.01	7.79	17.42	84.39	64.42	4.57	2.50
Punjab	2.43	7.56	–	2.25	5.13	9.02	58.37	26.93	5.8	1.64
Rajasthan	2.64	17.82	7.95	8.98	8.83	12.67	56.96	36.29	5.25	1.72
Tamil Nadu	7.88	37.32	12.62	13.25	4.2	14.18	39.82	62.34	4.34	4.31
Uttar Pr	6.28	37.88	–	12.21	22.86	47.93	53.11	38.41	5.97	2.07
West Bengal	5.11	15.08	9.97	12.44	4.34	9.63	37.01	42.26	3.03	2.78
All states	90.38	454.15	6.45	9.57	150.99	477.79	61.04	63.83	4.59	4.0

Source Finance accounts, Government of India, various issues (1981–2013)

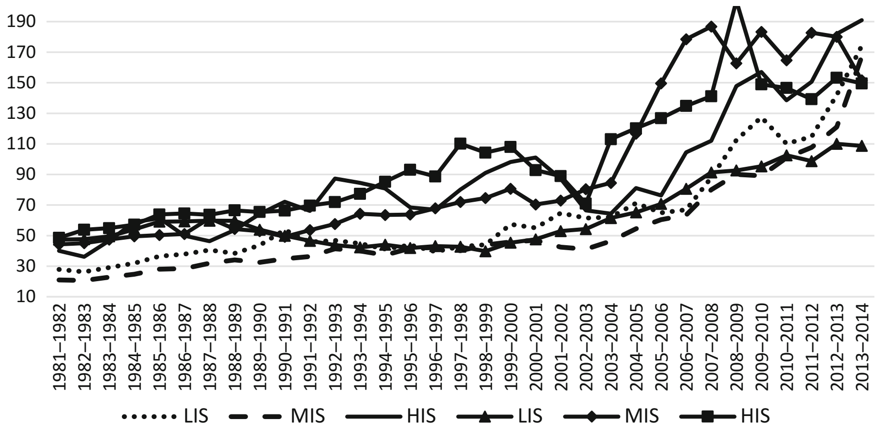

Fig. 2.1 Public expenditure on agriculture and irrigation (Rs. billion at constant (2004–05) prices). *Source* Bathla et al. (2017)

For greater clarity, states are also grouped into low, middle and high income based on average per capita income during the period 2000–13 (details given in Bathla et al. 2017). Accordingly, seven states fall under high-income category, five each in the middle- and low-income categories. Low-income states (LIS) include Bihar, Uttar Pradesh, Assam, Jammu & Kashmir and Madhya Pradesh; medium-income states (MIS) are Odisha, Rajasthan, West Bengal, Andhra Pradesh and Karnataka; and high-income states (HIS) include Punjab, Himachal Pradesh, Tamil Nadu, Kerala, Gujarat, Haryana and Maharashtra. Figure 2.1 depicts the magnitude of expenditure in agriculture and irrigation has significantly increased in every state since early 2003–04. But it has shown a consistent increase in the less developed agriculturally dependent states, which is a welcoming policy initiative by the respective state governments.

Despite a manifold increase in public spending on both revenue (current) and capital accounts, an important concern is that the latter, which is primarily towards capital formation (synonymous with investment), has not increased in a significant manner. Taking all states together, the percentage share of capital expenditure in total expenditure on agriculture has increased from 6.45 to 9.57% and on irrigation from 61.04 to 63.83% (Table 2.1). A significant increase in capital spending on irrigation is visible only in Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu and West Bengal. A lesser share of investment indicates that government expenditure is more towards day-to-day administrative expenditures including subsidies. According to Chandrasekhar and Ghosh (2002), a consistent cut in expenditure on capital account during the 1990s and a concomitant hike in current expenditure were possibly to achieve targeted fiscal deficit, which might have affected investments in key sectors. Although one may see a revival in spending from 2003–04, the capital intensity continues to be the same in agriculture and irrigation in each state with a few exceptions. As such, the share of capital expenditure in development expenditure remains low at 15% which persists at the sectoral level as well. Lower share of capital expenditure in total expenditure may also imply mounting bureaucracy and inefficiency, especially on major and medium canal irrigation systems (Bathla 2016).

As shown in Table 2.2, there has been a change in the composition of spending on agriculture towards food storage–warehousing, forestry and medium irrigation. The main subheads relate to agricultural and allied services include crop husbandry, forestry, livestock development and medium irrigation within the irrigation and flood control. Expenditure for TE 2014 shows the share of crop husbandry is the maximum in most of the states at nearly 34% in low-income state (LIS), and high-income states (HIS) and 39.8% in middle-income states (MIS), followed by forestry (15.3%), animal husbandry, food storage (10.6 and 11.98%) and cooperation (9.63%). Expenditure on dairy development has decelerated since the 1990s while large amount of resources seems to have been diverted to activities such as food storage and warehousing and research. One may see a much higher share of food storage and warehousing in total agriculture expenditure. It is relatively higher in LIS and MIS at 15 and 11.6% than that in HIS at 5.5% which could be explained by a larger number of poor in LIS and MIS and hence government intervention for stocking food.

The agriculture R&D share is less than 10% in HIS and much lower in other groups at 6%. This is worrisome given a deceleration in productivity growth of many crops and also the fact that R&D activity in agriculture is hardly undertaken by the private sector in the country. As share of agricultural GDP, India spends 1% on agri-R&D which is fairly low in comparison with its 3% share in the developed countries. Even if agricultural R&D is expanded by taking expenditure on soil conservation, crop and animal husbandry, its share in GSDP agriculture reaches to maximum 2%. This may have serious implications for agriculture and food production in the future.

Further, among various types of irrigation expenditures, the highest share is occupied by medium and major irrigation system across the states. The LIS spend more on minor irrigation and its share in total expenditure on irrigation stands at 27.68% during TE 2013–14 compared to 4.81 and 16.64% in MIS and HIS. MIS spend substantially on flood control that is visible from its high proportion in total irrigation expenditure at 62.8%. This may have also cut down spending on irrigation. The annual rate of growth in minor irrigation is much higher at 11.95% compared to that in the major–medium irrigation systems at 5.75%. An increasing investment in minor irrigation, mainly tanks and tube wells, can be explained by long gestation periods in the construction of canals and also growing inefficiency. It is an important step, especially knowing that the marginal efficiency of capital is much higher in minor irrigation than that in major–medium irrigation in each state (Bathla 2016).

In the face of large interstate variations in public expenditure on agriculture and irrigation, it is important to see it on per hectare basis. Table 2.3 provides estimates on agriculture R&D, irrigation (excluding flood control) along with private investment in agriculture as these heads have direct bearing on agricultural

Table 2.2 Composition of public expenditure in agriculture and % share of each at constant (2004–05) prices

	TE 2014				Annual % growth rate 2000–13			
	LIS	MIS	HIS	All	LIS	MIS	HIS	All
Agriculture (Rs. billion)	143.65	131.95	174.5	454.15	8.77	10.64	7.82	8.93
% share of:	100	100	100	100				
Crop husbandry	33.99	39.8	33.6	35.39	10.98	16.08	10.66	12.31
Soil and water conservation	4	2.64	6.15	4.35	2.22	2.18	8.67	5.03
Animal husbandry	10.58	9.88	11.11	10.59	7.62	6.65	8.46	7.78
Dairy development	1.32	2.74	3.19	2.44	15.59	9.32	−7.13	−2.02
Fisheries	1.91	2.23	3.73	2.65	8.95	6.52	11.94	9.56
Forestry and wildlife	19.94	13.33	13.14	15.36	5.89	5.0	4.67	5.31
Food, storage and warehousing	14.06	12.43	9.15	11.98	8.42	13.69	–	14.14
Agricultural research and education	5.48	5.77	9.23	6.92	8.2	7.35	6.99	7.31
Cooperation	8.46	10.67	9.53	9.63	14.91	13.66	9.72	12.58
Others	1.11	0.52	1.18	0.94	–	10.24	7.2	9.89
Irrigation (Rs. billion)	129.36	188.93	157.17	477.79	8.18	8.14	4.76	6.91
% share of	100	100	100	100				
Minor	27.68	4.81	16.64	19.15	11.95	9.17	9.58	10.32
Medium–major	56.29	31.2	76.77	71.76	5.75	8.11	3.73	5.89
Command area dev.	2.53	1.2	1.3	1.83	7.5	2.41	2.15	4.32
Flood control	13.5	62.8	5.29	7.25	15.86	8.38	12.88	12.71

Source Bathla et al. (2017)

Table 2.3 Expenditure on agriculture and irrigation and GSDPA per ha (Rs. at 2004–05 price)

	Agriculture R&D		Irrigation		Private investment agriculture		GSDPA/ha	
	TE 1984	TE 2014	TE 1984	TE 2014	1981–82	2012–13	TE 1984	TE 2014
Andhra Pradesh	164	1838	1376	10,106	604	1250	29,036	73,554
Assam	574	2183	686	2128	257	512	39,650	64,126
Bihar	240	2432	1347	3071	237	540	24,879	77,697
Gujarat	191	1620	1332	4561	468	1762	22,181	46,279
Haryana	286	1281	1481	2910	961	1611	29,855	84,905
Himachal Pr	2043	5351	803	5626	663	7772	52,546	146,581
J&K	780	4969	1959	4646	550	2273	55,462	100,751

(continued)

Table 2.3 (continued)

	Agriculture R&D		Irrigation		Private investment agriculture		GSDPA/ha	
	TE 1984	TE 2014	TE 1984	TE 2014	1981–82	2012–13	TE 1984 TE 2014	
Karnataka	161	1770	920	3646	406	1659	19,083	44,632
Kerala	706	4398	1600	2193	1147	5447	51,187	99,014
Madhya Pr	138	762	615	1891	224	1173	9329	37,312
Maharashtra	211	1560	1093	3790	399	1843	11,219	38,100
Odisha	260	2301	1222	3719	120	558	25,778	55,511
Punjab	318	1049	1082	1868	1602	2799	36,762	87,533
Rajasthan	61	532	553	714	282	1256	10,327	27,969
Tamil Nadu	572	4341	729	2150	745	1076	25,486	69,263
Uttar Pr	182	1195	1265	2537	684	2791	27,043	61,590
West Bengal	297	1264	596	1037	253	593	34,956	109,749
Total States	222	1532	1012	3206	471	1645	20,956	54,827

Note Public expenditure is on revenue and capital accounts. Irrigation head excludes expenditure on flood control; Private investment relates to 1981–82 and 2012–13 when All India Debt and Investment Survey (AIDIS) was done
Source Finance accounts, Government of India, various issues

productivity and growth. The estimates show a sizeable increase in spending on these heads in each state. At the national level, a seven times increase in public expenditure on agriculture R&D and three times increase in irrigation has taken place from TE 1984–85 to TE 2014–15, the absolute amount being Rs. 1532/ha to Rs. 3206/ha. Large interstate differentials in spending on agriculture R&D are perceptible, the highest in Himachal Pradesh and J&K at Rs. 5351 and Rs. 4968 and lowest at Rs. 532/ha in Rajasthan. One state viz. Andhra Pradesh spends the maximum amount on irrigation (Rs. 10,106/ha), while Rajasthan a rainfall scant state spends the least at Rs. 714/ha. Clearly, the developed states spent more which is obvious due to higher economic growth in these states and hence better spending power. One may see that agricultural R&D expenditure is high in the poor and rich states, at more than Rs. 2300/ha, respectively, compared to nearly Rs. 1500 among the middle-income states. The states that have low average per ha public investment in the recent period include Assam, Bihar, Kerala, Madhya Pradesh, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. Similar to public spending, private investment has also increased significantly from Rs. 471/ha in 1981–82 to Rs. 1645/ha in 2012–13. In case of private investment, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Maharashtra and Punjab have made significant strides, perhaps due to better banking infrastructure and opportunities. Barring UP, the less developed states continue to lag behind, which indicates a strong need to increase the flow of credit to these states.

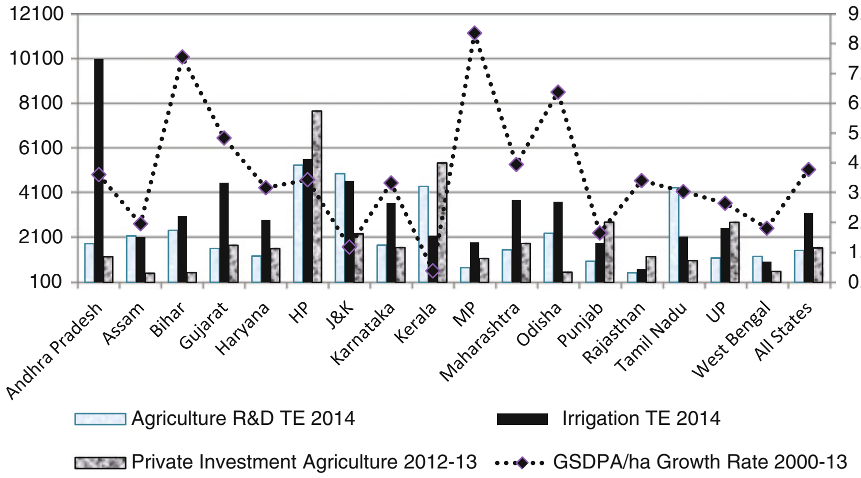

Fig. 2.2 Per ha public expenditure and private investment on agriculture and annual rate of growth in GSDPA (2000–13). *Source* Finance accounts (various years) AIDIS and NAS

Similar to investments, the interstate heterogeneity is perceptible in gross income from agriculture and allied activities. The per ha GSDPA has significantly increased from Rs. 20,956 during TE 1984–85 to Rs. 54,827 during TE 2014–15 by 3.1% per annum during 1981–82 to 2014–15. The states where agriculture growth is above national average include Andhra Pradesh, Madhya Pradesh, Himachal Pradesh, Haryana, Rajasthan, Maharashtra and West Bengal. Among other states, Assam, Odisha and Uttar Pradesh lagged behind slightly. However, over the past decade, many less developed states have surpassed the national average rate of growth in income. As depicted in Fig. 2.2, agriculture income in Bihar, Madhya Pradesh and Odisha have grown to almost 9% per annum from 2000–01 to 2013–14. Compared to the 1990s, the agricultural growth has undoubtedly picked in each state to reach close to 3.5% per annum. Perhaps, low capital intensity in public expenditure partly explains a slow pace of agricultural growth in some states. To what extent can an increase in agriculture income be attributed to higher public spending on agriculture and irrigation? The following section provides empirical findings of this relationship.

2.3 Empirical Estimates on Impact of Public Expenditure on Agriculture Growth

The analysis is undertaken from 1981 to 2013 based on OLS and GMM models using the double-log functional form. The regression results presented in Table 2.4 show that the dependent variable GSDPA is positively affected by the key explanatory variables, viz. public expenditure on agriculture R&D and irrigation. Taking state fixed effects and time into consideration, the estimated coefficient of R&D (0.016) is positive but statistically insignificant and that on public irrigation (0.12) is significant at 1% level. It indicates that a 10% increasing in government

Table 2.4 Empirical estimates from 1981 to 2013 at constant (2004–05) prices

Dependent variable	Log GSDP agriculture per capita	
Independent variables:	**OLS**	**Difference GMM**
Lagged GSDPA/capita	0.48* (0.058)	0.51* (0.069)
Public exp. agriculture R&D/ha	0.016 (0.017)	0.05* (0.19)
–Lagged	–	−0.026 (0.024)
Public exp. irrigation/ha	0.12* (0.018)	−0.084 (0.11)
–Lagged	–	0.19*** (0.11)
Private investment agriculture/ha	−0.20* (0.084)	−0.13*** (0.08)
–Lagged	0.21* (0.084)	0.12*** (0.07)
GSDP non-agriculture/capita	0.082* (0.027)	0.34** (0.17)
–Lagged	–	−0.29*** (0.17)
Land (GCA)	0.37* (0.068)	0.35* (0.085)
Labour/ha	0.041*** (0.024)	0.038** (0.02)
Rainfall	0.052* (0.02)	0.05*** (0.03)
Constant	−0.91 (0.89)	
State fixed effects	Yes	Yes
Year effects	Yes	Yes
Adjusted R^2	0.94	–
Hansen test *P*-value	–	Prob > chi2 = 1.000
Sargan test	–	Prob > chi2 = 0.359
AR1 test *P*-value	–	−2.80 Pr > z = 0.005
AR2 test *P*-value	–	2.12 Pr > z = 0.034
No. of states	17	17
No. of observations	544	527

Note Variables specified in log. *, ** and *** denote statistical significance at 1, 5 and 10% level, respectively
Figures in parentheses are standard errors. Public expenditure on irrigation excludes flood control. Public expenditure on agriculture and irrigation are capital stocks

spending on irrigation can increase agriculture income by 1.2%. The positive signs of coefficients also suggest that composition of spending matters as R&D head is broadened to include soil conservation and crop and animal husbandry, whereas irrigation is condensed to take minor–medium–major command area development and exclude flood control. Besides public investment, income is also influenced by lagged private investment with a much higher elasticity at 0.21. Among land, labour and weather variables, the most important turns out to be land having the highest elasticity at 0.37. Non-agriculture income also stands important in raising agriculture income (elasticity 0.082). These factors together explain nearly 94% of the variations in agriculture income as indicated by adjusted R^2. The impact of economic reforms captured through a dummy (1 from 1991 to 0 otherwise) turned out to be insignificant and hence dropped from the equation.

Estimated results from GMM specification confirm that agricultural income is positively and significantly determined by all the explanatory variables. One to two periods lagged levels of each variable are used as instruments in the difference equation. A few diagnostic tests are done to check the robustness of the estimates. The Hansen's test for over identifying restrictions as well as the AR test for no second-order serial correlation are passed at 1% level of significance. Sargan test was performed for over-identification of the equation, and test results show it to be identified. The estimated coefficients on land, labour and weather remained unchanged, whereas the value of key variables differ from that obtained in the OLS specification.

Public spending on agriculture R&D turns out to be significant in raising income under GMM (elasticity 0.05) as compared to the OLS. The elasticity of irrigation is also higher at 0.19. Similarly, non-agriculture income shows a higher magnitude of effect on agriculture income in the GMM specification. Importantly, in both OLS and GMM, the value of lagged dependent variable is not close to one, which indicates erratic changes in agriculture income across the states, possibly due to high dependence on weather conditions and state-specific policy interventions. The analysis substantiates the literature available at the national level in India and in some developing economies on a significant and positive relationship between public investment and agriculture income (Armas et al. 2012; Fan and Rao 2008). Similar to the Indonesian study, it also points towards the significance of composition of public spending within the agricultural sector in India.

2.4 Conclusion

The main objective of this chapter is to empirically examine the relationship between public investments in agriculture and irrigation and income in the Indian context. The analysis is based on a time series of public expenditures on agriculture R&D and irrigation for 17 major states from 1981–81 to 2013–14 using OLS and GMM techniques. The analysis reveals that low and inadequate public capital formation during the nineties impinged upon farmers' investments and jeopardized technological change and agricultural growth. A big push in resource allocation towards agriculture and irrigation from 2003–04 is an important policy initiative. Significant increase in expenditure on irrigation system in the less developed states has helped to turn around deceleration in productivity growth and upturn private investment and income.

Large interstate variations in public spending on agriculture and irrigation continue, showing richer (developed) states tend to spend more compared to the poorer (less developed) agriculturally dependent states, barring Himachal Pradesh and Jammu & Kashmir. Notwithstanding such interstate disparities in spending on agriculture and irrigation, the empirical analysis reveals their positive and significant impact on agriculture income. Both OLS and GMM approaches show consistent results. However, GMM specification shows the estimated coefficient on public spending on agriculture R&D and irrigation to be much higher at 0.05 and 0.19, respectively, in impacting agriculture income. It also brings forth the importance of composition of public spending in agriculture. The study points towards an urgent need to accord due priority to the agricultural sector in the fiscal policy. It recommends an increased resource allocation to the poorer states and capital deepening for accelerating farm productivity and income.

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