Ind. Jn. of Agri. Econ.
Vol.74, No.1, Jan.-March 2019

From Food Security to Farmers' Prosperity: Challenges, Prospects and Way Forward*

Pratap S. Birthal†

I

INTRODUCTION

Fuelled by technological change and backed by investment in irrigation, infrastructure (e.g., roads and electricity) markets and institutions (e.g., credit and extension) and enabling policies India experienced tremendous increase in agricultural productivity and food supplies that propelled the country into food self-sufficiency from a situation of acute food shortages in the 1960s and 1970s. Between 1966-67 and 2016-17 production of foodgrains increased by three-fold (from 95 to 275 million tonnes), of fruits and vegetables by seven-fold (from 40 to 268 million tonnes) and of milk by eight-fold (from 20 to 163 million tonnes). On the whole, agricultural sector during this period grew at an annual rate of around 3 per cent that helped millions of rural people escape poverty (Datt and Ravallion, 1998; Datt *et al*., 2016).

Despite such a revolutionary progress in agriculture the economic condition of farmers remains deplorable on account of several factors, such as the declining scale of production, deceleration in technological gains, increasing frequency of extreme climatic events (e.g., droughts, floods and heat-waves), rising input prices, increasing volatility in food prices and lack of income opportunities in non-agricultural sectors. The per capita income of farmers is just one-fifth of the national per capita income, and a majority of them, especially those at the bottom of land distribution, are stuck in a low-income trap. For them, the prospects of staying in agriculture are not sanguine—approximately half of them have a latent desire to quit agriculture as a profession, but they continue with it because of little opportunities for employment outside agriculture (Birthal *et al*., 2015a).

Anticipating that the consequences of continued agrarian distress could be disastrous for the nation's food security and economic growth, the Union government in its annual budget of 2016-17 indicated a transition in agri-food policy towards improving the economic conditions of farmers, shedding excessive emphasis on food production, and set a target to double their incomes by 2022-23. Given the huge mass

*Keynote paper presented at the 78th Annual Conference of the Indian Society of Agricultural Economics held under the auspices of Institute of Economic Growth at NASC Complex, IFPRI, New Delhi, November 1-3, 2018.

†ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi-110 012.

of small-scale producers, this indeed is a laudable step, and has attracted considerable attention in policy debates. These debates centre around the prospects and challenges in meeting the target, and a common inference that emerges is that in the absence of strategic investments and innovations in farm sector and its linkages with non-farm sector it would be difficult to achieve the target in such a short period of time. Chandrasekhar and Mehrotra (2016) and Satyasai and Bharti (2016), on the assumption of the continuance of past trends, have estimated a time period of 14 years to double farmers' income. Alternatively, if the target has to be achieved by 2022-23, farmers' income has to grow at least at 10 per cent a year.

Towards this, both the Union and state governments have taken several measures, such as promotion of micro-irrigation systems, crop insurance, horticulture and animal husbandry; restoration of soil health; linking farmers to markets and incentives for development of value chains; raising support prices of important crops; increasing flow of institutional credit, and creation of employment opportunities outside agriculture. The underlying assumption is that all the farmers, irrespective of their economic status and geographical location, would benefit from these interventions.

However, farmers are heterogenous in several aspects that matter for their incomes. They differ in their resource endowments (e.g., land, labour, capital, education, skills, etc.), and access to innovations, information, institutions and infrastructure. Thus, a universal strategy of 'one size fits all' is likely to suffer from the targeting errors, both of exclusion and inclusion, as has been observed in several government programmes in the past, for example in the public distribution system (Swaminathan and Misra, 2001; Khera, 2008).

Achieving the goal of doubling farmers' income or enhancing it to a significant degree in such a short period of time would not only require resources but also a change in policy stance. One such change is the identification and profiling of low-income or resource-poor farmers and their locations along several dimensions such as ownership of their assets and production portfolios and access to technologies, inputs, extension services, credit and markets that matter for their farm productivity, and also to the income-generating activities outside agriculture. Profiling of the farmers along such dimensions would provide a series of strategies and policy choices. This paper does exactly that.

Rest of this paper is organised as follows. Next section discusses the key challenges being confronted by the farmers and other stakeholders in their efforts to improve efficiency and sustainability of agriculture. In Section III we present the farmers' profiles for understanding the heterogeneity in the socio-economic characteristics and locations, and look for prospects towards rapid increase in their incomes. Conclusions and implications are discussed in the last section.

II

KEY CHALLENGES

Growing Competition for Land: Supply of land is fixed, and the competition for land has been intensifying due to its growing demand in non-agricultural activities like housing, manufacturing and infrastructure. From 6.2 per cent in 1975-76 the share of non-agricultural land in the total land area has increased to 8.7 per cent in 2014-15. On the other hand, the net sown area has almost stagnated around 141 million hectares. If these trends in the land use pattern persist probably some of the cultivable land may be diverted to non-agricultural activities. Besides, the qualitative deterioration of land resources due to intensification of agriculture is posing a big challenge to sustainable increase in farm productivity and farmers' income.

*Small yet Squeezing Scale of Productio*n: Agriculture is dominated by smallholders, and the landholdings have been proliferating with a concomittment decline in their size. Between 1981 and 2011 the number of landholdings increased from 89 million to 140 million and their average size declined from 1.84 hectares to 1.15 hectares. The number of landholdings measuring less than or equal to one hectare almost doubled raising their share to 67 per cent in the total land holdings. If this trend continues unabated, for majority of the households the agriculture-based livelihoods are likely to be untenable.

Growing Stress on Water Resources: Water resources are scarce. According to an estimate by the World Resources Institute about 54 per cent of India's land is water-stressed (WRI, 2015), more so in the north-western region, the sheet of India's green revolution. Of the potential availability of water of 1869 billion cubic meters (bcm) about 1123 bcm (690 surface and 433 groundwater) is utilisable. Agriculture, with a share of 85 per cent in the total water demand (813bcm), is the largest consumer of water. Notably, agriculture is increasingly becoming dependent on groundwater — of the total irrigated area in 2014-15 about 61 per cent depended on groundwater — a reversal of the trend five decades ago. Further, irrigation alone accounts for 90 per cent of groundwater withdrawal and is responsible for its over-exploitation. About 29 per cent of the groundwater blocks in the country have been over-exploited or are approaching towards extensive limit of over-exploitation. According to a study by the World Bank (2005) if the rate of groundwater extraction remains unabated about 60 per cent aquifers in the country would go dry by 2025.

Increasing Frequency of Extreme Climatic Events: Climate change is emerging as a big threat to sustainable development of agriculture and agriculture-based livelihoods. By 2035 agricultural productivity under changed climate is likely to be 6 per cent less (Birthal *et al*., 2014a), ranging from 1 per cent to 10 per cent across crops (Birthal *et al*., 2014b). The consequences of extreme climatic events (droughts, floods, cyclones and heat waves), frequency of which is predicted to increase (World Bank, 2013; Birthal *et al*., 2015b) will be more severe. Not only that changes in climate would induce greater risks of insect pests and diseases, in terms of their

increased resurgence and resistance to pesticides, and also emergence of new pest strains.

Increasing Energy Scarcity: Agriculture uses considerable amount of energy, directly and indirectly, and it is becoming energy-intensive. Between 1980-81 and 2006-07 commercial energy consumption in Indian agriculture increased six-fold, from 3.04 thousand MJ (mega joules) to 18.48 thousand MJ per hectare, the maximum increase being for electricity and diesel (Jha *et al*., 2012). Prices of electricity, petrol and diesel have been increasing, and their growing demand will push up energy prices further. While the rising prices of energy inputs will add to the cost of production, their lesser use will adversely affect agricultural productivity.

Increasing Pressure on R&D System: Future agriculture will be knowledge- and information-intensive, implying an explosion in farmers' demand for information. Until now, India's agricultural R&D system has focused on raising crop yields, but less on stress-tolerance and natural resource management. Further, linkages between research and its dissemination systems are weak—60 per cent farm households do not have access to information on modern agricultural technologies and practices (Birthal *et al*., 2015c). The outreach of government extension system is limited only to 7 per cent of the households. The emerging discourse suggests that agricultural growth will no longer be a single path, but will require many paths for sustainable intensification. This means are-orientation of agricultural research agenda encompassing multiple disciplines and a greater focus on basic and strategic research, and improving outreach and efficiency of agricultural services.

Financing Smallholders: Finance has been one of the major constraints to sustainable growth of smallholder agriculture in the past, and is likely to remain in the forseeable future. Credit requirements of smallholders are trivial, the financial institutions because of the higher transaction costs and lending risks associated with small amounts hesitate to provide loans to them. Also, there is a bias in the allocation of institutional credit; the high-value, high-growth poor-poor segments of agriculture such as animal husbandry (including fisheries) and horticulture together receive about 5 per cent of the total institutional credit or 15 per cent of the total investment credit as against their share of more than 50 per cent in the total value of agricultural output.

Imperfections in Domestic Markets: The growth in market infrastructure has not kept pace with the growth in agricultural production (Chand, 2012) making farmers vulnerable to the exploitation by traders in informal as well as formal markets (Negi *et al*., 2018; Meenakshi and Banerji, 2005). Further, the increasing volatility in agricultural prices and consumer concerns for safe and quality food are posing a significant challenge to farmers' participation in market-oriented agri-food systems. Global agri-food markets are integrating, but there is an apprehension that in the absence of appropriate institutional arrangements and social safety nets, the small-scale producers, entrepreneurs and processors will be more affected by globalisation.

Continued Excessive Employment Pressure on Agriculture: Agriculture continues to be excessively burdened with workforce. It still engages about half of the total

workforce. Furthermore, the technological gains that kept farmers engaged on agriculture during the first few decades of green revolution have started diminishing—annual growth in average yield of food grains has decelerated to 1.7 per cent during 1996-97 to 2014-15 from about 3 per cent during 1981-82 to 1995-96, and the employment elasticity in agriculture has reached closer to zero (Chadha, 2008).

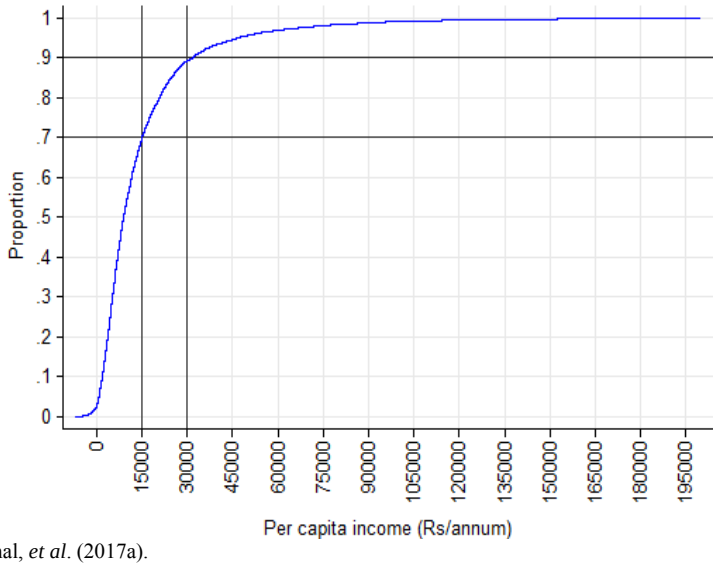
III

FARMERS' INCOME: STATUS AND PROSPECTS FOR GROWTH[1]

3.1 *Level and Distribution of Income*

The farm household surveys conducted by the National Sample Survey Office (NSSO) are the only source of information on farmers' income and other attributes. Until now, only two rounds of such surveys have been conducted, one in 2002-03 (Government of India, 2006) and another in 2012-13 (Government of India, 2014). In our analysis, we make use of data from the latter round of the survey.

The per capita income of Indian farmers was Rs. 14470 per annum in 2012-13, just one-fifth of the all India per capita income (Figure 1). Not only that the income distribution among farmers is highly inegalitarian. About 70 per cent of the farm households have per capita income less than the average for all the farm households.



Source: Birthal, *et al*. (2017a).

Figure 1. Cumulative Distribution of Per Capita Income of Farmers, 2012-13.

As expected land size is an important correlate of farmers' income. The per capita income of marginal farmers, who cultivate landholdings less than or equal to

one hectare and comprise about 70 per cent of the total farmers, is Rs.11346. The small (1-2 hectares), medium (2-4 hectares) and large farmers (>4 hectares) have income levels 1.4, 2.0 and 3.1. times of the income of the marginal farmers.

Land although important, is not the only source of income for farmers. They earn from several other sources also. On an average, farm households obtain 48 per cent of the income from crops, 32 per cent from wages and salaries, 12 per cent from animal husbandry and 8 per cent from non-farm business activities. However, the relative income shares of these sources vary across land classes—the share of non-farm income sources is inversely related to farm size. Hence, a sustainable income-growth strategy should take into consideration distribution of land as well as non-land based income sources. Table 1 presents a two-way classification of the households based on land size and per capita income. Approximately three-fourths of the households in the low-income class (less than or equal to Rs.15000 per capita income) belong to marginal farm category (Table 1a). *Prima facie*, it is this group of farmers that should be targeted in income growth strategies. Note, the marginal farm households by virtue of their dominance in the agrarian structure also dominate the higher income classes. For example, about 7 per cent of them earn as much as do the large farm households (Table 1b). Their per capita income is about 8 times more than their counterparts in low-income class (Table 1c). In the following paragraphs, we identify the causes of such a large difference in incomes of marginal farmers, who have pretty much similar landholdings.

TABLE 1. DISTRIBUTION OF FARM HOUSEHOLDS BY THEIR STATUS IN LAND-INCOME CLASS

(1)	Low-income (≤Rs.15000) (2)	Middle -income (Rs.15001- 30000) (3)	High-income (>Rs.30000) (4)	All (5)
		(a) Within income classes (per cent)		
Marginal (≤1ha)	74.54	55.60	41.71	69.77
Small (1-2ha)	15.91	23.11	19.63	17.12
Medium (2-4ha)	7.17	14.71	21.29	9.22
Large (>4ha)	2.38	6.58	17.37	3.89
All	100.00	100.00	100.00	100.00
		(b) Across income classes (per cent)		
Marginal (≤1ha)	77.30	16.10	6.61	100.00
Small (1-2ha)	62.74	25.44	11.82	100.00
Medium (2-4ha)	49.35	28.28	22.38	100.00
Large (>4ha)	34.69	26.71	38.60	100.00
All	69.84	19.50	10.66	100.00
		(c) Per capita income (Rs.)		
Marginal (≤1ha)	6067	20639	50478	11346
Small (1-2ha)	7191	21026	55318	16399
Medium (2-4ha)	7717	21436	54842	22142
Large (>4ha)	7366	22574	68284	34941
All	6395	20972	55450	14470

Source: Birthal, *et al*. (2017a).

3.2 *Factors Differentiating Marginal Farmers' in Their Incomes*

Table 2 presents key factors that can potentially distinguish marginal farmers in their income levels, despite no significant difference in their landholdings. Farm productivity, measured as net returns per hectare, for high-income marginal farmers is almost thrice of their counterparts in the low-income class.

TABLE 2. KEY CHARACTERISTICS DIFFERENTIATING MARGINAL FARMERS IN THEIR INCOMES

(1)	Low-income (2)	Middle-income (3)	High-income (4)	All (5)
Landholding size (ha)	0.41	0.44	0.45	0.42
Gross returns (Rs./ha)	46230	70047	105149	5468
Net returns (Rs./ha)	25655	45683	79420	33084
Cost of cultivation (Rs./ha)	20575	24364	25729	21602
Gross cropped area (ha)	0.59	0.65	0.73	0.61
Per cent cropped area irrigated	65.47	61.36	57.45	64.17
Per cent area under high-value crops	6.30	8.91	14.59	7.41
Per cent area under food grains	73.68	54.95	49.73	68.49
Per cent households engaged in livestock production	47.14	58.33	59.32	50.08
Per cent households engaged in non-farm business	7.77	16.48	20.72	10.33
Per cent households receiving wages and salaries	52.08	69.44	73.59	56.84
Caste of the households (per cent)				
Scheduled tribes	12.52	13.63	12.96	12.7
Scheduled castes	20.21	17.06	16.53	19.3
Other backward castes	45.66	43.95	43.09	45.1
Upper castes	21.60	25.36	27.42	22.72
Family size (number)	5.13	4.48	4.18	4.94
Number of adult workers per household	3.02	3.10	3.08	3.04
Education level of the household-head (per cent)				
Illiterate	45.98	40.61	33.50	44.05
Primary school	25.45	26.08	22.79	25.35
Middle school	14.23	11.41	15.34	13.82
Secondary school	7.78	11.07	12.01	8.69
Higher secondary school	3.70	5.29	6.77	4.23
Graduate and above	2.21	5.10	9.41	3.28
Per cent households having outstanding loans	45.22	55.37	51.06	47.48
Per cent households having access to information	39.44	44.71	50.50	41.24

Source: Birthal, *et al*. (2017a).

There could be several factors for such a huge difference in farm productivity within the marginal farm class. They have a more diversified production portfolio towards crops, such as fruits, vegetables, plantations, medicinal plants, condiments and spices that generate higher returns to land compared to cereals or other widely grown crops. They also cultivate their lands more intensively. Animal husbandry is

widely practiced, but more by the high-income farmers. Further, the high-income farmers are also more engaged in labour market and non-farm business activities.

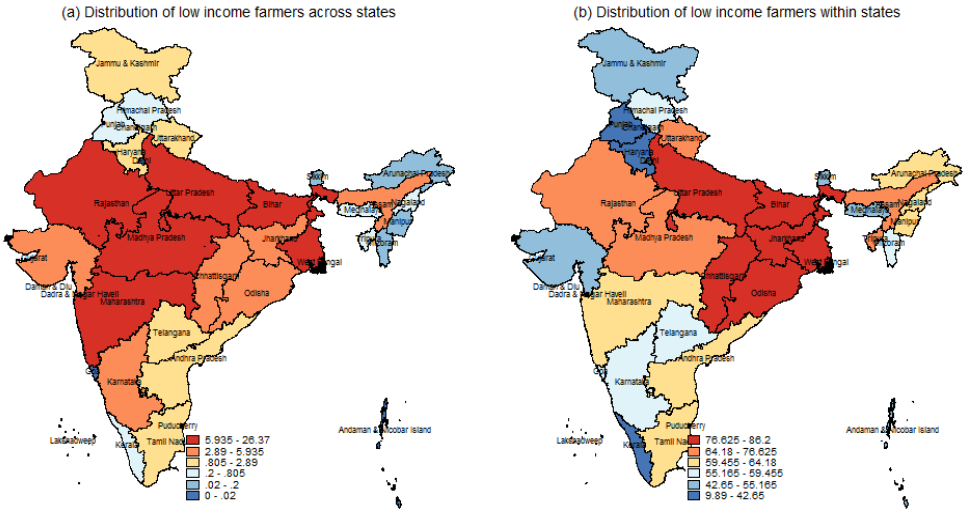
Returns on investment in crop production seem quite attractive. The resource poor farmers, however, are constrained by a lack of access to institutional credit, information, markets and infrastructure, and theyalso have low-level of management skills or education essential to the adoption of improved technologies and quality inputs to reach the productivity levels of high-income farmers (Table 2). There is evidence that the farmers who have access to institutional credit earn 19 per cent more than those who borrow from informal sources (Kumar *et al*., 2017). Also those who have access to information on modern agricultural technologies and practices realise 12 per cent higher net income (Birthal *et al*., 2015c). Further, the access to information helps farmers bargain better prices from both formal and informal markets (Negi *et al*., 2018).

A part of the variation in marginal farmers' income could also be on account of the differences in demographic and social attributes. Lanjouw and Lanjouw (2001) and Foster and Rosenzweig (2004) have shown that small gains in educational attainment can bring significant improvements in rural incomes. Our findings show that the heads of the high-income households having a higher level of schooling compared to those in the low-income class. The social status, based on caste, religion and ethnicity, can also differentiate them in their incomes *via* ownership of resources, and access to technology, information and credit (Batte and Arnholt, 2003; Ali, 2012; Kumar, 2013; Birthal *et al*., 2017b). Caste is an important determinant of social status in India, with scheduled caste/tribe being the bottom and other backward castes in the middle of the social hierarchy. We, however, do not find caste a significant differentiation of marginal farmers' incomes.

3.3 *Location of Low-Income Farmers*

A majority of low-income marginal farm households (57 per cent) are located in the eastern region, including the states of Bihar, Jharkhand, Odisha, West Bengal and eastern Uttar Pradesh,[2] that has been bypassed by green revolution (Figure 2, Table 3). Uttar Pradesh alone accounts for more than a quarter of low-income marginal farmers, followed by Bihar (11 per cent), West Bengal (10 per cent), Odisha (6 per cent) and Jharkhand (3 per cent). Another 20 per cent low-income marginal farmers are located in the western and central states of Rajasthan, Maharashtra, Gujarat, Madhya Pradesh and Chhattisgarh. The low-income marginal farmers comprise around 80 per cent of the total farmers in the eastern region, and about 70 per cent in the central region and western regions. The southern region comprising states of Andhra Pradesh, Telangana, Karnataka, Tamil Nadu and Kerala, accounts for about 11 per cent of the total low-income marginal farmers, and in these states they make up around 60 per cent of the total farmers, except Kerala where their proportion is just one-third. Rest of the low-income marginal farmers are distributed almost

equally between the northern (Punjab, Haryana, Himachal Pradesh, Jammu and Kashmir and Uttarakhand) and north-eastern (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura) regions.



Source: Birthal *et al*. (2017a).

Figure 2. Spatial Distribution of Low-Income Farmers (per cent), 2012-13.

Do low-income marginal farmers vary in their income levels across states? Interestingly, there is no significant variation in their incomes despite significant regional differences in the average income of overall pool of farmers (Table 3). The per capita income of farmers in the eastern states is much less than the all-India average, while those of in Punjab, Kerala, Haryana and Jammu and Kashmir is more than twice of the all-India average. This clearly suggests that the strategies for enhancing farmers' income should concentrate on eastern states that have a higher concentration of resource-poor marginal farmers.

There could be several factors behind regional variation in farmers' income (Appendix Table). The states that are at the bottom of income hierarchy have smaller landholdings, but comparatively higher endowment of irrigation. Irrigation, however, is uncertain, and does not seem to compensate much for the income differences due to scale. Cropping intensity is also low in these states.

Investment in agricultural research is a high payoff activity, in terms of its impact on agricultural growth and poverty reduction (Fan *et al*., 2008). Unfortunately, in several states the level of spending on agricultural research is low. For example, it is less than Rs. 500 per hectare of net sown area in Rajasthan, Madhya Pradesh, Chhattisgarh, Maharashtra, Odisha, Jharkhand, West Bengal and all north-eastern states. On the other hand, some states that have a higher level spending on agricultural research lack supporting infrastructures and institutions essential for income growth. For example, Jammu & Kashmir, Himachal Pradesh, Kerala and

TABLE 3. SPATIAL DISTRIBUTION OF LOW-INCOME FARMERS, 2012-13

	Low-income farmers (LIMF)		Low-income marginal farmers (LIMF)		Per capita income (Rs.)	
State	Per cent of all-India	Per cent of total farmers in the state	Per cent of all-India	Per cent of total low-income farmers	LIMF	All farmers
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bihar	10.5	86.2	11.4	88.0	5204	8626
Uttar Pradesh	26.4	81.7	27.4	86.0	5098	11131
Uttarakhand	1.2	75.9	1.6	80.4	6088	11597
West Bengal	6.9	79.0	9.9	79.1	6327	11599
Jharkhand	3.0	81.7	3.2	78.3	6351	12836
Chhattisgarh	3.2	78.4	2.5	84.7	6796	12897
Odisha	5.0	77.3	6.3	79.8	6653	14047
Tripura	0.2	69.2	0.3	70.0	7446	15568
Madhya Pradesh	7.0	70.4	5.3	80.2	7061	15745
Assam	3.5	65.6	3.9	76.1	6608	16854
Rajasthan	7.0	65.3	5.8	74.8	7679	17301
Maharashtra	6.8	62.0	4.3	64.7	6788	18561
Gujarat	3.3	51.2	2.6	50.8	8241	19311
Manipur	0.2	60.3	0.2	69.5	4672	19481
Andhra Pradesh	2.8	63.1	2.5	61.4	7271	19671
Telangana	2.0	58.7	1.7	61.0	7101	19878
Sikkim	0.1	55.0	0.1	52.0	7881	20800
Tamil Nadu	2.5	60.2	3.1	61.0	6977	21913
Mizoram	0.1	55.5	0.1	61.9	7311	22436
Karnataka	3.7	55.8	2.9	58.0	6154	22476
Nagaland	0.3	61.1	0.2	51.6	7234	23768
Arunachal Pradesh	0.1	61.3	0.1	75.0	5088	24505
Himachal Pradesh	0.7	57.3	1.0	58.7	7455	25829
Meghalaya	0.3	43.5	0.2	41.3	9178	26506
Jammu & Kashmir	0.9	44.3	1.0	43.6	7202	30058
Haryana	1.2	41.8	1.0	52.7	6961	31176
Kerala	0.6	33.0	0.9	36.2	5407	35553
Punjab	0.7	32.2	0.8	44.7	5682	43941
All-India	100.0	100.0	100.0	74.54	6067	14470

Source: Birthal, *et al*. (2017a).

Karnataka spend more on agricultural research but have smaller landholdings and irrigation levels. Interestingly, these states rank higher in income hierarchy because of the compensating variation coming from diversification into high-value crops and non-farm activities.

Most eastern states, have reasonably good connectivity but lack in complementary infrastructure, for example electric power, that restricts farmers capturing benefits of the investments in roads. Electricity consumption in agriculture in Odisha, Bihar and Jharkhand hardly exceeds 65 KWh/ha. Most north-eastern states are deficit in all types infrastructure. On the other hand, the central and western states are better placed in roads and power, but have under-developed markets.

Institutional support (credit and extension) to agriculture is also poor in north-eastern and eastern states. For example, hardly one-third of the farm households in Uttar Pradesh, Jharkhand, Odisha and north-eastern states have access to information on modern agricultural technologies and practices, and mostly from sources other

than the government sources (extension workers, Krishi Vigyan Kendras, veterinary departments and research institutions).

We investigate the relationship between infrastructure and farmers' income level by estimating correlation between the incidence of low-income farmers and proportion of villages in a district having different types of infrastructure (Table 4). The correlation coefficients between the proportion of low-income farmers and infrastructural variables are negative and significant, while these are positive and significant for other income classes. These findings clearly indicate that there is a crucial link between infrastructure and farmers' income.

TABLE 4. CORRELATION COEFFICIENTS BETWEEN FARMERS' INCOMES AND INFRASTRUCTURE ACROSS DISTRICTS

(1)	Low-income (2)	Middle- income (3)	High-income (4)
Electricity	-0.408***	0.325***	0.298***
Telephone lines	-0.424***	0.338***	0.309***
Mobile connectivity	-0.323***	0.262***	0.231***
Pucca road	-0.172***	0.163***	0.102**
All-weather road	-0.231***	0.239***	0.118***
Commercial bank	-0.353***	0.236***	0.300***
Cooperative bank	-0.318***	0.205***	0.276***
Mandi/market	-0.038	0.027	0.032

Source: Birthal, *et al*. (2017a).
*** and ** denote significance at 1 and 5 per cent level, respectively.

Besides infrastructure, the urbanisation and human capital also matter for agricultural growth and rural development (Lanjouw and Murgai 2009; Himanshu *et al*., 2011). The level of urbanisation is extremely low in poorer states — 11 per cent in Bihar, 14 per cent in Assam, 17 per cent in Odisha, 22 per cent in Uttar Pradesh, and around 25 per cent in Rajasthan, Chhattisgarh and Madhya Pradesh. Rural literacy rate is also low in these states.

An important observation that emerges from this discussion is that one or the other indicator of infrastructure development is fairly robust in several of the poorer states, but they lack in complementary infrastructures that restrict farmers capturing benefits of the investment in other infrastructures. For example, in Bihar there is a good network of rural roads (to provide farmers' access to markets), but farmers do not benefit much from it because of lack of power required for pumping water for irrigation. This clearly suggests a need for a multi-pronged, integrated strategy encompassing research, infrastructure and institutions to bridge the developmental gap between poor and rich states.

IV

WAY FORWARD

From profiling of farmers and their locations along several dimensions we arrive at some important conclusions for targeting growth strategies. First, it is the marginal

farmers, three-fourths of whom stay at the bottom of income distribution, should be at the forefront of any developmental strategy. Second, the efforts and investments should concentrate more on eastern region that has lagged behind in agricultural and economic development and is home to about 60 per cent of the total low-income marginal farmers. Third, there are prospects of raising farmers' income within agriculture by improving resource use efficiency and diversifying production towards high-value crops and animal husbandry. Finally, for majority of households, farming alone is not sufficient to escape low-income trap, and recourse has to be with the development of rural non-farm sector. With these conclusions in mind, we suggest some important interventions for sustainable improvements in farming and farmers' income.

The scope for income growth through area expansion is limited, hence the agricultural policy should emphasise exploiting agriculture on its intensive margins a lot. Currently, only about 40 per cent of the country's net cropped area is cultivated more than once, and also there is a wide variation in it across states and farm classes. This needs to be raised by improving farmers' access to reliable irrigation sources and seeds of short-duration high-yielding crops/varieties befitting the existing cropping systems.

Irrigation is important for raising farm productivity; and given the acute scarcity of water the recourse has to be with improving water-use efficiency, which is 30-40 per cent for surface irrigation and 60-70 per cent for groundwater irrigation. Modern methods of irrigation, viz. sprinkler and drip systems can reduce water and energy consumption by 12-84 per cent and 29-45 per cent, respectively and without any yield penalty. Currently, only about 9 million hectares of area is irrigated through micro-irrigation systems, much less than the potential of 42 million hectares (Palanisami *et al*., 2011). In the same vein, the conservation technologies, such as zero-tillage and laser-levelling and water scheduling devices (e.g., tensiometer) improve water and nutrient-use efficiency (Jat *et al*., 2009; Vatta *et al*., 2018), reduce cost of production and improve crops' resilience to extreme climatic events, such as droughts and heat waves.

Further, given extensive limits on the use of non-renewable energy resources, there course has to be with the methods of improving energy-use efficiency and exploiting renewable energy resources, for example, solar and wind power. Vatta *et al*. (2018) have shown that scheduling of irrigation through tensiometer can save electric power by 13 per cent. Also there is a considerable scope to convert agricultural waste into energy. Agriculture generates 686 million tonnes of crop residues, of which one-third is available for electricity generation, and if this amount is utilised for electricity generation it can meet 17 per cent of the total primary energy demand in the country (Hiloidhari *et al*., 2014). India has also huge livestock population producing 2600 million tonnes of dung a year that can be used to produce 263702 million cubic meter of biogas or 476 terawatt hours of electricity (Kaur *et al*.,

2017). Converting waste into energy requires investment in infrastructure. Solar farming is a potential source of energy as well as of income for farmers.

If farmers' incomes have to be enhanced to a significant degree in a shorter period, the status quo in terms of primacy of cereals has to give way to diversification towards high-value high-growth pro-poor sectors, such as horticulture and animal husbandry (Birthal *et al*., 2015d; Birthal and Negi, 2012). The sustained rise in per capita income and expanding urbanisation are triggering rapid growth in demand for high-value food commodities including animal products (Joshi and Kumar, 2016). Notwithstanding their pro-poor growth potential, high-value crops and animal husbandry have not received much policy attention. For example, animal husbandry and horticulture together account for more than half of the total value of agricultural output but share hardly 5 per cent of the total loan advances to agriculture. Credit for these activities is treated as investment credit, and hardly there is any provision for short-term credit to meet operational expenses. Livestock sector also remains under-invested—it receives hardly 10 per cent of the total public investment in agricultural sector. The extension support to these sectors is almost negligible, for example, hardly 5 per cent of livestock farmers have access to information on livestock technologies and practices. There are frequent outbreak of diseases causing huge loss to production, despite significant improvement in veterinary infrastructure and manpower. This calls for improving outreach and efficiency of livestock services. The focus should be on prophylactic management of diseases.

To make markets competitive and remunerative for farmers the Union government has taken several initiatives to bring in transparency in price discovery and to develop value chains through institutional arrangements (e.g., farmer producer organisations (FPOs) and contract farming). These institutions need to be promoted aggressively so as to improve transparency in price discovery, to reduce trade cost associated with small surpluses, and to reduce farmers' dependence on informal traders and input dealers for credit.

Of late, the Union government has decided to fix minimum support prices (MSP) of important crops 1.5 times of the cost of production (Cost A2 plus implicit cost of family labour). This is unlikely to benefit much the farmers as the government procures only rice and wheat (about one-third of the total production) and small quantities of pulses and coarse cereals. A number of commodities, including fruits, vegetables and milk that make sizable proportion of farmers' income remain outside the purview of price policy. The past experiences also show that hardly 10 per cent of the farmers, mostly large farmers, sell their produce to government agencies. Recently, the government has also raised minimum support prices of pulses, but farmers have not benefitted from this. Most of the time, the farm harvest prices have remained below MSP. Government is also experimenting with price deficiency scheme that compensates farmers for the difference between MSP and farm harvest price. Notwithstanding its novelty, this scheme has been manipulated by traders and commission agents to their advantage. Since, farmers are compensated for the

difference between MSP and farm harvest price, traders deliberately keep farm harvest price low to benefit from higher prices later. Such malpractices need to be curbed strictly enforcing the market regulations, providing farmers an access to warehouses (by lowering the stock limits) and encouraging private agribusiness firms to invest in value chains.

An important issue from the point of view of augmenting farmers' income relates to their differential access to information. In many ways, the access to information pitches farmers among technology adopters more than the ones driven by large-scale programmes for input subsidies and crop insurance. The mobile connectivity is widespread in rural areas, its potential for dissemination of information has remained underexploited. In view of the limited outreach of the government extension system, the mobile and internet can serve an important vehicle for dissemination of information. Farmers need a bundle of information, and, therefore, the need is to develop backend infrastructure for compilation, processing and dissemination of information.

There is a crucial link between infrastructure and farmers' income, but lack of complementarities among different infrastructures restrict farmers capturing benefits of the existing infrastructures. This implies a need for holistic development of infrastructure taking into consideration the complementarities among different types.

To arrest qualitative deterioration of natural resources there is a need to develop region-specific crop plans taking into consideration their endowments and demand for agricultural commodities. This will help to conserve natural resources, manage price volatility and ensure remunerative prices to the farmers. Incentives are needed to enable farmers to shift towards less resource intensive crops.

There is a need felt to re-look into the policies that have spurred agricultural growth but has resulted in unintended negative externalities to natural resources. MSP and input subsidies (fertiliser, irrigation and power) are claimed to distort cropping pattern and deplete groundwater. Although, it is not politically feasible to do away with these incentives, but these can be repackaged and linked to promotion of the technologies and practices that enhance sustainability of the production systems. The other option is to club all such incentives and provide farmers a comprehensive farm support.

There are policies that are in conflict with other policies. For example, the policies that incentivise farm mechanisation are in direct conflict with the policies for preservation of indigenous cattle, a source of draught power for agriculture. Indiscriminate lending by commercial banks for mechanisation has reduced the utility of draught animals and also led to over-capitalisation of small farms in some states like Punjab and Haryana. Cattle slaughtering is banned and farmers are forced to maintain draught animals despite their high maintenance cost. To overcome the problem of surplus cattle, the option is to promote of sex semen technology that provides farmers a choice of desired sex of the offspring. At present, the technology

is imported, and is costlier, and there is an urgent need to invest in research on sex semen technology.

In the long-run, boost to farmers' income must come from technological breakthroughs that push yield frontiers, enhance resource use efficiency, reduce cost of production and improve resilience of agriculture to climate change. This means more allocation of resources for agricultural research, improvements in efficiency of research and reorientation of research agenda to address the emerging challenges. Currently, India spends only about 0.6 per cent of its agricultural GDP on agricultural research and development (Beintema *et al*., 2012). This needs to be raised at least 1 per cent of the agricultural GDP.

Agriculture can no longer support additional workforce. For sustained rise in farmers' incomes there is a need to lower the load on agriculture by expanding the non-farm sector. If the constraint due to ubiquitous smallholdings were to be mitigated the strategies for broad-based growth of rural non-farm sector would be required. There is considerable scope for rural industrialisation as agriculture generates considerable surpluses for manufacturing of value-added products. The expanding rural non-farm sector will create opportunities for investment in ancillary industries related to inputs, equipment, machines and support services, and generate incomes for investment in farm production. Investment in human capital and value chains will be a key to rural industrialisation.

NOTES

1) This section is heavily drawn from Birthal *et al*. (2017a).

2) Agriculture in the western Uttar Pradesh is more developed than eastern Uttar Pradesh, and we presume that a majority of low-income farmers are located in its eastern part.

REFERENCES

Ali, J. (2012), Factors Affecting the Adoption of Information and Communication Technologies (ICTs) for Farming Decisions, *Journal of Agricultural & Food Information,* Vol.13, No.1, pp.78-96.

Batte, M.T. and M.W. Arnholt (2003), Precision Farming Adoption and Use in Ohio: Case Studies of Six Leading-Edge Adopters, *Computers and Electronics in Agriculture,* Vol.38, pp.125–139.

Beintema, N.; G.J. Stads, K. Fuglie and P. Heisey (2012), ASTI Global Assessment of Agricultural R&D Spending, International Food Policy Research Institute, Washington D.C., U.S.A.

Birthal, P.S. and D.S. Negi (2012), "Livestock for Higher, Sustainable and Inclusive Agricultural Growth", *Economic and Political Weekly*, Vol.47, No.26-27, 30 June, pp.89-99.

Birthal, P.S.; D.S. Negi, S. Kumar, S. Agarwal, A. Suresh and Md. Tajuddin Khan (2014a), "How Sensitive is Indian Agriculture to Climate Change?", *Indian Journal of Agricultural Economics*, Vol.69, No.4, October-December, pp.474-487.

Birthal, P.S., Md. Tajuddin Khan, D.S. Negi and S. Agarwal (2014b), "Impact of Climate Change on Yields of Major Food Crops in India: Implications for Food Security", *Agricultural Economics Research Review,* Vol.27, No.2, pp.145-155.

Birthal, P.S.; D. Roy, Md. Tajuddin Khan and D.S. Negi (2015a), "Farmers' Preference for Farming? Evidence from a Nationally Representative Farm Survey in India", *The Developing Economies,* Vol.53, No.2, pp.122-134.

Birthal, P.S.; D.S. Negi, Md. Tajuddin Khan and S. Agarwal (2015b), "Is Indian Agriculture Becoming Resilient to Droughts?", *Food Policy,* Vol.56, pp.1-12.

Birthal, P.S.; S. Kumar, D.S. Negi and D. Roy (2015c), "The Impact of Information on Returns from Farming: Evidence from a Nationally Representative Farm Survey in India", *Agricultural Economics,* Vol.46, pp.1-13.

Birthal, P.S.; D. Roy and D.S. Negi (2015d), "Assessing the Impact of Crop Diversification on Farm Poverty in India", *World Development,* Vol.72, pp.70-92.

Birthal, P.S.; D.S. Negi and D. Roy (2017a), *Enhancing Farmers' Income: Who to Target and How*? Policy Paper 30, National Institute of Agricultural Economics and Policy Research, New Delhi.

Birthal, P.S.; R. Chand, P.K. Joshi, R. Saxena, P. Rajkhowa, Md. Tajuddin Khan, Mohd. Arshad Khan and K.R. Chaudhary (2017b), "Formal Versus Informal: Efficiency, Inclusiveness and Financing of Dairy Value Chains in Indian Punjab", *Journal of Rural Studies,* Vol.54, pp.288-303.

Chadha, G.K. (2008), *Employment and Rural Poverty in India: Which Way to Go Now*?, ILO Asia-Pacific Working Paper Series, New Delhi-SRO.

Chand, R. (2012), "Development Policies and Agricultural Markets", *Economic and Political Weekly*, Vol.47, No.52, 29 December, pp.53-63.

Chandrasekhar, S. and N. Mehrotra (2016), "Doubling Farmers' Income by 2022: What Would it Take?", *Economic and Political Weekly,* Vol.51, No.18, 30 April, pp.10-13.

Datt, G. and M. Ravallion (1998), "Farm Productivity and Rural Poverty in India", *Journal of Development Studies*, Vol.34, No.4, pp.62-85.

Datt, G.; M. Ravallion and R. Murgai (2016), *Growth, Urbanization and Poverty Reduction in India*, Policy Research Working Paper 7568, The World Bank, Washington D.C., U.K.

Fan, S.; A. Gulati and S. Thorat (2008), "Investment, Subsidies, and Pro-Poor Growth in Rural India", *Agricultural Economics*, Vol.39, No.2, pp.173-170.

Foster, A. and M. Rosenzweig (2004), "Agricultural Productivity Growth, Rural Economic Diversity, and Economic Reforms: India, 1970-2000", *Economic Development and Cultural Change*, Vol.52, No.3, pp.509-542.

Government of India (2006), *Income, Expenditure and Productive Assets of Farmer Households*, National Sample Survey Office, Ministry of Statistics and Programme Implementation, New Delhi, India.

Government of India (2014), *Key Indicators of Situation of Agricultural Households in India*, National Sample Survey Office, Ministry of Statistics and Programme Implementation, New Delhi, India.

Government of India (2016), *Agricultural Statistics at a Glance,* Directorate of Economics and Statistics, Ministry of Agriculture and Farmers' Welfare, New Delhi, India.

Hiloidhari, M.; D. Das and D.C. Baruah (2014), "Bioenergy Potential from Crop Residue Biomass in India", *Renewable and Sustainable Energy Reviews*, Vol.32, pp.504-512.

Himanshu; P. Lanjouw, A. Mukhopadhyay and R. Murgai (2011), *Non-farm Diversification and Rural Poverty Decline: A Perspective from Indian Sample Survey and Village Study Data*, Asia Research Centre, Working Paper 44, London School of Economics, London, U.K.

Jat, M.L.; M.K. Gathala, J.K. Ladha, Y.S. Saharawat, A.S. Jat, V. Kumar, S.K. Sharma, V. Kumar and R.K. Gupta (2009), "Evaluation of Precision Land Levelling and Double Zero-Till Systems in the Rice–Wheat Rotation: Water Use, Productivity, Profitability and Soil Physical Properties", *Soil and Tillage Research,* Vol.105, No.1, pp.112-121.

Jha, G.K., S. Pal, and A. Singh (2012), "Changing Energy-Use Pattern and the Demand Projections for Indian Agriculture", *Agricultural Economics Research Review*, Vol.25, No.1, pp.61-68.

Joshi, P.K. and P. Kumar (2016), Food Demand and Supply Projections for India, in Floor Brower and P. K. Joshi (Eds.) (2016), *International Trade and Food Security: The Future of Indian Agriculture,* CAB International, Wallingford, U.K.

Kaur, G.; Y.S. Brar and D.P. Kothari (2017), "Potential of Livestock Generated Biomass: Untapped Energy Source in India", *Energies*, Vol.10, pp.3-15.

Khera, R. (2008), "Access to the Targeted Public Distribution System: A Case Study in Rajasthan", *Economic and Political Weekly*, Vol.43, No.44, 1 November, pp.51-56.

Kumar, A.; A.K. Mishra, S. Saraoj and P.K. Joshi (2017), *Institutional vs Non-Institutional Credit to Agricultural Households in India: Evidence on Impact from a National Farmers' Survey*. IFPRI Discussion Paper 01614, International Food Policy Research Institute, Washington D.C., U.S.A.

Kumar, S.M. (2013), "Does Access to Formal Agricultural Credit Depend on Caste?", *World Development*, Vol.43, No.3, pp.315–328.

Lanjouw, J.O. and P. Lanjouw (2001), "The Rural Non-Farm Sector: Issues and Evidence from Developing Countries", *Agricultural Economics*, Vol.26,No.1, pp.1-23.

Lanjouw. P. and R. Murgai (2009), *Poverty Decline, Agricultural Wages, and Non-farm Employment in India: 1983-2004*, Policy Research Working Paper No.4858. World Bank, Washington, D.C., U.S.A.

Meenakshi, J. V. and A. Banerji (2005), "The Unsupportable Support Price: An Analysis of Collusion and Government Intervention in Paddy Auction Markets in North India", *Journal of Development Economics*, Vol.76, No.2, pp.377-403.

Negi, D.S.; P.S. Birthal, D. Roy and Md. Tajuddin Khan (2018), "Farmers' Choice of Market Channels and Producer Prices in India: Role of Transportation and Communication Networks", *Food Policy* (forthcoming).

Palanisami, K.; K. Mohan, K.R. Kakumanu and S. Raman (2011), "Spread and Economics of Micro-Irrigation in India: Evidence from Nine States", *Economic and Political Weekly*, Vol.46, No.26-27, 25 June, pp.81-86.

Satyasai, K.J.S. and S. Bharti (2016), "Doubling Farmers' Income: Way Forward", Rural Pulse (March-April), National Bank for Agriculture and Rural Development, Mumbai, India.

Swaminathan, M. and N. Misra (2001), "Errors of Targeting Public Distribution of Food in a Maharashtra Village, 1995-2000", *Economic and Political Weekly,* Vol. 36, No.26, 30 June, pp.2447-54.

Vatta, K.; R.S. Sidhu, U. Lall, P.S. Birthal, G. Taneja, B. Kaur, N. Devineniand and C. MacAlister (2018), "Assessing the Economic Impact of a Low-Cost Water-Saving Irrigation Technology in Indian Punjab: the Tensiometer", *Water International,* Vol.43, No.2, pp.305–321.

World Bank (2005), *India's Water Economy: Bracing for a Turbulent Future*, World Bank, Washington, D.C., U.S.A.

World Bank (2013), *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience*, The World Bank, Washington D.C., U.S.A.

WRI (Water Resources Institute) (2015), India's Growing Water Risks, Available at: http://www.wri.org/blog/2015/02/3-maps-explain-india%E2%80%99s-growing-water-risk.

APPENDIX

TABLE A1. INDICATORS OF INFRASTRUCTURE AND INSTITUTIONAL DEVELOPMENT

State	Land holding(ha), 2012-13	Irrigation (per cent), 2013-14	Cropping intensity (per cent), 2012-13	Research & education spending (Rs/ha), 2013-14	Electricity consumption KWh/ha), 2013-14	Market density (km/1000sq.km), 2013-14	Per cent area insured, 2014-15	Per cent farmers accessing information-All sources	Per cent farmers accessing information-Govt. sources	Per cent villages connected with pucca road	Per cent villages having commercial bank	Per cent villages having cooperative bank	Per cent villages have telephone lines	Per cent villages having mobile phone connectivity	Rural literacy (per cent)	Urban population (per cent)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Bihar	0.60	67.9	144	826	64	19.1	48.0	43.4	6.1	75.4	19.1	11.6	38.6	59.0	59.8	11.3
Uttar Pradesh	0.66	78.8	156	671	556	16.8	8.0	30.2	5.2	75.1	8.2	5.5	40.0	78.4	65.5	22.8
Uttarakhand	0.49	49.5	159	1949	550	1.2	4.6	26.2	11.2	58.4	9.1	10.5	61.3	94.9	76.3	30.6
West Bengal	0.44	58.9	186	267	239	39.8	10.3	52.7	10.1	52.2	13.8	7.6	60.2	88.7	72.1	31.9
Jharkhand	0.63	14.2	118	584	60	10.1	14.8	32.1	3.2	95.7	8.8	6.3	12.8	53.2	61.1	24.1
Chhattisgarh	1.24	30.7	122	187	539	8.4	33.1	54.7	27.3	76.6	5.3	8.0	36.6	71.3	66.0	23.2
Odisha	0.74	29.1	116	261	36	9.9	33.4	36.7	16.5	76.6	1.9	2.8	71.5	97.6	70.2	16.7
Tripura	0.72	26.8	144	38	155	52.8	0.1	32.5	29.1	88.8	13.0	9.8	60.4	79.4	84.9	26.2
Madhya Pradesh	1.44	41.2	151	127	650	4.3	45.9	42.7	9.9	69.9	8.2	11.0	40.2	80.8	63.9	27.6
Assam	0.90	9.1	149	669	12	14.5	0.7	57.1	25.1	50.2	12.6	8.3	32.2	80.3	69.3	14.1
Rajasthan	1.78	37.8	137	93	1048	2.2	49.7	30.4	9.2	55.0	36.3	37.4	87.0	99.9	61.4	24.9
Maharashtra	1.56	19.5	126	401	1272	14.2	22.3	42.5	17.5	91.1	24.5	29.2	92.9	98.4	77.0	45.2
Gujarat	1.28	47.6	122	584	1454	1.7	11.0	52.8	17.6	97.9	22.8	14.5	93.0	98.1	71.7	42.6
Manipur	0.86	18.2	100	123	3	5.3	2.1	30.4	9.3	62.1	1.7	0.8	35.1	86.8	76.2	30.2
Andhra Pradesh	1.48	50.4	123	544	1793	3.3	4.0	68.2	30.9	97.1	32.4	15.7	93.5	96.4	67.4	29.6
Telangana	1.53	50.3	118	665	-	-	-	37.9	5.9	98.2	23.8	15	86.8	96.9	57.3	38.9
Sikkim	0.67	8.6	194	15	Neg	2.7	Neg	0.5	0.1	87.9	12.5	4.2	85.9	99.9	79.0	25.0
Tamil Nadu	0.90	56.1	113	1232	2475	7.5	16.3	49.9	25.7	98.5	16.3	24.3	94.9	98.8	73.5	48.5
Mizoram	1.04	14.2	100	1043	1	5.5	Neg	34.4	21.9	48.2	8.8	2.5	29.5	75.3	84.1	51.5
Karnataka	1.65	33.5	120	504	1754	4.9	12.3	69.9	42.2	95.7	19.2	8.3	98.0	92.6	68.7	38.9
Nagaland	1.11	20.0	129	410	Neg	11.6	Neg	21.7	5.8	37.5	3.1	0.1	23.7	93.0	75.4	29.0
Arunachal Pradesh	1.68	19.3	132	548	Neg	1.0	Neg	22.7	15.6	37.2	4.7	1.5	33.9	54.1	59.9	22.7
Himachal Pradesh	0.56	21.2	174	2908	138	1.4	5.6	42.9	29.2	72.6	12.9	13.8	89.1	91.0	81.9	10.0
Meghalaya	1.06	37.0	119	386	1	5.5	0.4	23.5	15.1	55.2	4.3	2.5	23.0	75.6	69.9	20.1
Meghalaya	1.06	37.0	119	386	1	5.5	0.4	23.5	15.1	55.2	4.3	2.5	23.0	75.6	69.9	20.1
Jammu & Kashmir	0.50	42.9	156	5132	398	0.1	Neg	53.0	36.4	61.4	11.9	5.6	45.2	84.2	63.2	27.2
Haryana	1.41	88.2	181	741	2357	10.7	Neg	43.6	21.1	97.3	22.9	22.4	94.7	100	71.4	34.8
Kerala	0.60	17.9	127	1719	94	35.1	1.7	66.0	40.7	100	86.4	96.8	100	100	93.0	47.7
Punjab	1.53	98.5	190	809	2597	35.7	Neg	46.9	29.9	92.9	18.5	21.2	89.1	98.7	71.4	37.5

Note: Data on irrigation, cropping intensity, and electricity consumption are from Government of India (2016); on research and education spending from (RBI: https://rbi.org.in/Scripts/AnnualPublications.aspx?head=State%20Finances%20:%20A%20Study%20of%20Budgets); rural literacy and urban population from 2011 Census; and on all others from Government of India (2014).