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Growth and Instability in Agricultural Productivity: A District Level Analysis§

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This study has examined the trends in growth and instability in Indian agriculture at the district level and has identified distinctive features and drivers of productivity growth across districts. The productivity of crop sector has shown tremendous variations across districts both for the country as a whole and within a state. The varying performance of crop sector has emphasized the need for evolving regionally differentiated strategies for ensuring sustainable and inclusive agricultural growth in a state and consequently in the country. The instability in productivity continues to persist and there are wide variations in instability across different districts. To mitigate the consequences of persisting instability, large-scale promotion of stabilization measures like insurance should be pursued vigorously. The analysis of district level data has revealed the important role of modern inputs in enhancing the productivity of crop sector. The use of fertilizers has turned out to be the most important input. Along with fertilizer-use, rainfall, irrigation, source of irrigation, better human resources and road connectivity have emerged as the other critical determinants of agricultural productivity. These results signify the importance of use of modern inputs and prudent management of rainfall water, particularly in the low productivity districts.

Key words: District, productivity, growth, instability

JEL Classification: Q10, Q16, Q18

Introduction

Understanding the regional pattern of agricultural growth and development helps to evolve strategic decentralized development strategies to ensure inclusive growth in the country in the long-run. However, the regional pattern of agricultural growth and development in India has been studied mostly at the state level (Sawant and Achutan, 1995; Sawant, 1997; Singh *et al.,* 1997; Chand, 1999; Ahluwalia, 2000; Mathur *et al.*, 2006; Kumar and Elumalai *,* 2007; Bhalla and Singh, 2009), although a few studies at district level exist (Dev, 1985; Bhalla and Alagh, 1979; Bhalla and Tyagi, 1989; Bhalla and Singh, 1997; Chand *et al.* 2009; Bhalla and Singh, 2010). Though, states are the appropriate administrative entity to study regional dimensions of agricultural growth and development, intra-state variations in performance of agriculture due to wide regional variations in resource endowments and climatic conditions within the state calls for understanding the pattern of agricultural growth at more disaggregated level. Recognising the importance of district level approach for agricultural development, Planning Commission has been giving emphasis on developing district level plan for agriculture development. Therefore, to have a pragmatic agricultural development planning and policy at lower administrative units, the district level study assumes importance. In this background, this study was undertaken to examine the trends in growth and instability in Indian agriculture at district level and tried to understand distinctive features and drivers of productivity growth across districts. The factors

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responsible for diversity in the performance of agriculture across districts were also analysed and discussed to explore policy and investment options at disaggregated level for accelerating agricultural productivity growth in India.

Data and Methodology

Data

The study is based on the secondary data compiled from various sources for the period from 1990-91 to 2007-08. The information on various correlates of district level growth and productivity was compiled from different web sites and publications brought out by the Directorate of Economics and Statistics, Ministry of Agriculture; the Department of Animal Husbandry, Dairying and Fisheries (DAHD&F); Ministry of Home Affairs; Reserve Bank of India; Fertiliser Association of India; Census of India; and different departments of various states.

Methodology

The physical output was converted into monetary terms by using state level implicit prices of various agricultural crops. These prices were generated by dividing the state level value of output of each crop estimated by Central Statistical Organization (CSO) by the output of that crop. To overcome the the effect of yearly fluctuations, a weighted average of three year prices for 2005-06, 2006-07 and 2007 was used to estimate the value of output for each crop for the triennium 2007. According to the CSO methodology, such prices reflect farm gate prices.

The crops considered in the study did not cover the entire area under cultivation. To account for the crop output of the residual area, the value of output for crops considered in this study was multiplied by the ratio of GCA_t/GCA_c, where GCA_t is the reported gross cropped area and GCA_c is the sum of area under the crops considered in the study. This gives the estimate of VCO_t for GCA_t. The value of crop output thus estimated was then divided by net sown area (NSA) to arrive at the per hectare productivity. The productivity per hectare of NSA, instead of GCA, includes the effect of crop intensity on productivity and provides estimates of productivity for the whole year. Thus, output/ha of net sown area refers to output/ha/year. The total value of output so derived has been used for subsequent analysis of growth and productivity at the district level. Further, to have a meaningful comparison over time, the districts existed in 1990 were retained and the districts came into existence after 1990 were merged with the parent districts and the relevant data were apportioned accordingly.

Results and Discussion

Agricultural growth is necessary not only for attaining high overall growth but also for accelerating the poverty reduction in a developing country like India. The annual compound growth rates of the agricultural sector have been quite robust ranging from 2 per cent to 3 per cent after independence. However, the non-agricultural sector has grown faster than the agricultural sector and the divergence between agricultural growth and overall economic growth has widened over time, particularly since 1980s. The India's total GDP growth accelerated from 3.3 per cent per annum in the 1980s to 6.0 per cent in the 1990s, and further to 7.8 per cent during the 2000s.

The agricultural productivity per unit of land (per hectare) has more than trebled during the past six decades, from ₹ 7003 in the TE 1952 to ₹ 22,944 in the TE 2008 at constant (1993-94) prices. The growth pattern of AgNDP/ha has, however, varied over time; it hovered between 1.1 and 1.5 per cent in the 1950s, 1960s and 1970s and then grew at more than 3 per cent per annum in 1980s, 1990s and 2000s. The per capita agricultural NDP (income) did not increase in the 1960s and 1970s. However, it improved subsequently. The agricultural income grew at the annual growth rate of 1.7 per cent and 1.6 per cent during 1990s and 2000s, respectively (Kumar and Jain, 2012). The critics of the Indian agricultural development strategies argue that the growth in agriculture is regionally concentrated, and it is confined to a few commodities. The disaggregated analysis of agricultural productivity would decipher these issues and will help in identifying and prioritizing the districts for agricultural development.

Agricultural Productivity: District Level Trends and Patterns

The district-wise agricultural productivity has been estimated for TE 1991, 2001 and 2007. The variation in the agricultural productivity was astonishing, it

Table 1. Distribution of districts and their share in net sown area and value of output: TE1991-TE 2007

Category of districts	No. of districts			Share in output and NSA (%)					
				Value of output			Net sown area		
	TE 1991	TE 2001	TE 2007	TE 1991	TE 2001	TE 2007	TE 1991	TE 2001	TE 2007
Very low (< ₹11000)	38 (9.4)	31 (7.6)	13 (3.3)	4.9	2.9	1.7	16.0	11.8	8.0
Low (₹11000-19000)	101 (25.0)	89 (21.8)	66 (16.8)	19.4	15.8	10.5	30.8	28.1	20.6
Average (₹19000-30000)	119 (29.5)	107 (26.2)	111 (28.2)	22.4	19.4	20.1	21.7	22.5	26.4
High (₹30000-41000)	101 (25.0)	114 (27.9)	113 (28.7)	32.4	34.8	30.7	22.4	25.0	24.6
Very high (> ₹41000)	45 (11.1)	68 (16.6)	91 (23.1)	20.9	27.1	37.0	9.0	12.6	20.4

Note: Figures within the parentheses indicate percentage of the total number of districts.

varied from only ₹ 1478/ha in the Barmer district of Rajasthan to ₹ 93936/ha in the Thanjavur district of Tamil Nadu during TE 1991. In 2001 the lowest productivity was of ₹ 2088 in Barmer district and the highest productivity was of ₹ 93771/ha in Karnal district of Haryana. The district Barmer continued to be the lowest in TE 2007 also with ₹ 2068/ha and Karnal recorded the highest productivity of ₹ 107376/ha. The crop productivity per unit of NSA in some of the most productive districts was more than forty-times higher than that of the districts having lower productivity.

To understand the patterns of productivity broadly, the districts were categorized into five productivity levels[1], viz. very low, low, average, high and very high. The distribution of districts during TE 1991, TE 2001 and TE 2007 is given in Table 1. In TE 1991, the highest number of districts had 'average' productivity (119), followed by 'high' and 'low' productivity districts (101 each), 'very high' (45) and 'low' (38) productivity districts. The pattern of distribution showed some distinct changes over time. The proportion of districts recording very low productivity declined substantially from 9.4 per cent in TE 1991 to 3.3 per cent in TE 2007. The share of low productivity districts in the total number of districts also declined from 25 per cent in TE 1991 to 17 per cent in TE 2007. However, there was no perceptible change in the proportion of districts falling under average and high productivity categories. On the other hand, the proportion of districts falling under the category of very high productivity increased from 11 per cent in TE 1991 to 23 per cent in TE 2007.

The share of different categories of districts in terms of VOC and NSA has undergone pereceptible changes over time. The districts under very low productivity category accounted for 16 per cent of NSA in TE 1991, 12 per cent in TE 2001 and 8 per cent in TE 2007. Their share in the crop output declined from 5 per cent in TE 1991 to 1.7 per cent in TE 2007. On the other hand, the share of very high productivity districts in NSA and VOC increased considerably with time. These districts accounted for 9 per cent of NSA in TE 1991, which increased to more than 20 per cent in TE 2007. Similarly, the share of these districts in VOC increased from 21 per cent to 37 per cent during this period. The increasing share of better performing districts indicate that increase in productivity is becoming widespread over time.

There have been remarkable changes in the category of both very low and very high productivity

[1] The average productivity included all those districts with productivity in the range of mean with ±0.25 standard deviation (SD). The very low and low classes were formed by taking the range as bottom of the average productivity less 0.5 and 1.0 times the SD. High and very high categories were selected by 0.5 and 1.0 times the SD to the upper limit of average productivity range. The districts were thus categorised crop productivity-wise as follows: < ₹ 11000/ha — very low; ₹ 11000-19000/ha — low; ₹ 19000-30000/ha — average; ₹ 30000-41000/ha — high; and > ₹ 41000/ha — very high.

Table 2. Average crop productivity for different categories of districts: TE 1991 – TE 2007

(₹/ha)

Category of districts	TE 1991	TE 2001	TE 2007
Very low	7264	7665	7429
Low	15018	15296	16043
Average	24346	23801	24267
High	33769	37722	39307
Very high	53802	58154	58610
Overall	26123	29994	34507

districts. The average productivity (₹ 53802) of the very high productivity districts was more than seven-times of the average productivity of the very low productivity districts in TE 1991. The gap between the top and bottom categories of districts remained wide over time and even in TE 2007, the average productivity of districts falling under very low productivity category was about one-eighth of the very high productivity districts (Table 2).

Not only across the states, even within a state a wide variation is seen in the productivity level of various districts. Even in smaller states, the existence of pockets of high and low productivity districts is apparent. The distribution of districts according to productivity status for major states has been presented in Table 3. In TE 2007, out of 22 districts in Andhra Pradesh, only one district was in the category of low productivity districts. In contrast to this, only 10 districts registered high productivity in TE 1991 and 13 districts were in either low productivity or average productivity groups. In TE 1991, Assam had 17 districts under average productivity category, 5 in low productivity category and only one district under high productivity category. However, in TE 2001 and TE 2007, the number of districts having high productivity increased to three. Still 74 per cent of the districts in Assam were in either low or average productivity category. The situation in Bihar was similar to Assam. In TE 1991, out of 29 districts in Bihar, only one district was in the category of high productivity, 9 were in low

Table 3. Inter-state distribution of districts by land productivity category: TE 1991–TE 2007

(Number)

State	TE 1991					TE 2001					TE 2007				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Andhra Pradesh	1	4	8	8	2	0	2	5	12	4	0	1	3	9	9
Assam	0	5	17	1	0	0	2	15	6	0	0	3	14	6	0
Bihar	0	9	19	1	0	0	9	16	4	0	0	9	17	2	1
Chhattisgarh	0	6	0	0	0	3	4	0	0	0	2	4	1	0	0
Gujarat	1	6	5	7	0	1	3	7	7	1	0	0	5	7	7
Haryana	0	0	1	5	10	0	0	1	6	9	0	0	0	7	9
Himachal Pradesh	0	1	4	5	2	0	0	3	5	4	0	0	3	5	4
Jammu and Kashmir	3	0	9	2	0	4	2	7	1	0	0	0	0	0	0
Jharkhand	4	5	1	0	0	6	5	0	0	0	0	2	5	1	3
Karnataka	4	10	4	2	0	0	8	9	2	1	0	8	7	4	1
Kerala	1	0	2	8	3	0	1	0	6	7	0	1	3	7	3
Madhya Pradesh	3	22	3	10	0	1	18	12	7	0	0	16	19	3	0
Maharashtra	8	15	5	1	1	4	13	8	3	1	1	10	12	3	3
Odisha	0	0	5	8	0	1	9	3	0	0	1	7	3	2	0
Punjab	0	0	0	1	11	0	0	0	0	13	0	0	0	0	13
Rajasthan	12	10	3	3	0	10	9	7	2	0	9	6	9	4	0
Tamil Nadu	0	2	3	5	9	0	2	1	7	10	0	2	0	9	9
Uttar Pradesh	0	5	19	27	2	0	2	6	37	10	0	4	9	32	10
Uttarakhand	0	0	8	1	0	0	0	5	3	1	0	0	3	3	3
West Bengal	1	1	3	6	5	1	0	2	6	7	1	0	1	5	9
Total	38	101	119	101	45	31	89	107	114	68	14	73	114	109	84

Notes: 1-very low; 2-low; 3-average, 4-high; 5-very high

productivity and the remaining 19 were in the average productivity category. No district witnessed very low or very high productivity. In TE 2001, the situation slightly improved when 4 districts could register high productivity. The situation remained, by and large, same in TE 2007 when only three districts (10%) were in the high productivity category. The situation of Chhattisgarh was similar to Assam and Bihar and none of the districts of Chhattisgarh could attain the high productivity level.

The districts in Gujarat depicted an interesting picture. In TE 1991, out of the 19 districts, seven recorded high productivity and the same number were in low productivity level. The situation remained almost same in TE 2001 with a slight improvement. However, in TE 2007, the situation completely changed when 14 districts (74%) recorded high productivity and the remaining 5 districts deplicted average productivity. No district remained in the low productivity range.

Haryana and Punjab along with Western UP have been the cradle of green revolution in the country. Therefore, most of districts in these regions were in the high productivity category. In TE 1991, out of 16 districts of Haryana, 10 recorded very high productivity, 5 were in high productivity and only one had average productivity. In TE 2007, the situation was still better when all the districts of Haryana were having high productivity level, 9 very high and 7 high. All the districts in Himachal Pradesh have above-average productivity with 58 per cent districts depicted high productivity in TE 1991. The percentage of high productivity districts in Himachal Pradesh increased to 75 per cent in TE 2001, with same situation in TE 2007. In Jammu & Kashmir, one-fourth of districts were in the low productivity category and the remaining were in either average or high productivity category. In Odisha, one-third districts each came under low, average and high productivity categories. In Madhya Pradesh and Maharashtra, the majority of districts in TE 1991 were in very low productivity. However, the situation in these two states changed over time and in TE 2007, more than 50 per cent of the districts in these two states became average or high productivity districts.

As expected, all districts in Punjab continued to be in the category of high productivity. In Rajasthan, 79 per cent of the districts in TE 1991 were in the category of low productivity. Though, the situation exhibited some improvement with time, still more than half of the districts continue to be in the low productivity category. The majority of districts (70 %) in Karnataka in TE 1991 were in the low productivity category. The proportion of districts falling under low productivity category declined sharply over time and in TE 2007, 40 per cent of the districts were in low productivity category, 55 per cent were in average productivity and one-fourth were in high productivity category. In Kerala and Tamil Nadu, the majority of districts remained in high productivity category. In Uttar Pradesh, 55 per cent of the districts were having high productivity level in TE 1991. The situation improved further with more than three-fourths of the districts recording high productivity. West Bengal could reap the benefits of green revolution from the beginning and the fruits of early adoption of green revolution technologies are reflected in the higher proportion of the districts recording high productivity in this state.

Growth in Agricultural Productivity

The growth of agricultural production has been estimated for the 1990s and 2000s. A compatible and consistent information for 388 districts was collected and these districts were divided into the five categories (like in productivity) on the basis of the compound annual growth rates recorded in their value of crop output per ha (Table 4). There seems to be a shift in districts across the growth categories during 1990s and 2000s. During 1990s, about 60 per cent of the districts recorded low growth (< 2.5 %) and 21 per cent of the districts recorded high growth rate of more than 3.5 per cent. During the 2000s, the proportion of districts under very low category did not change much but the number of districts under high growth category increased to 35 per cent.

It has been observed that the share of very slow growing districts in the crop output and gross cropped area is declining with time. The districts falling under very low category of growth rate accounted for 52 per cent of the value of output of crop in TE 1991, its share in TE 2007 declined to 44 per cent. These districts accounted for 47-48 per cent of the NSA during this period. The very low growth witnessed in almost half of the NSA is really a matter of concern for ensuring inclusive agricultural growth in the country. The share of high growing districts in the VOC has increased from 11 per cent in TE 1991 to 16 per cent in TE 2007 (Table 4).

Table 4. Share of districts in output and area by level of growth

Growth category of districts	Percentage of districts		Share of different categories of districts in Value of output (%)			Net sown area (%)		
	1990-99	2000-07	TE 1991	TE 2001	TE 2007	TE 1991	TE 2001	TE 2007
Very low	43.5	45.6	51.6	49.7	43.6	46.7	47.3	47.5
Low	18.2	8.5	21.7	22.3	22.2	20.4	20.3	20.5
Average	17.2	11.0	15.8	16.0	18.2	17.7	17.5	17.3
High	12.1	8.7	7.1	7.3	9.4	10.1	9.9	9.8
Very high	9.0	26.2	3.9	4.7	6.7	5.0	5.0	4.8

Very low: <1.5 per cent; Low: 1.5-2.5 per cent; Average: 2.5-3.5 per cent; High: 3.5-5.0 per cent and Very high: >5.0 per cent

Table 5. Trends in growth of output, yield and area: 1990-99 and 2000-07

Growth category of districts	Growth rate (per cent per annum)					
	1990-99			2000-07		
	Output	Area	Yield	Output	Area	Yield
Very low	-0.20	0.16	-0.36	-0.36	0.05	-0.41
Low	2.01	-0.05	2.06	2.14	0.36	1.77
Average	2.90	-0.03	2.92	3.74	0.61	3.11
High	3.61	-0.42	4.04	5.72	0.06	5.66
Very high	6.88	-0.33	7.24	10.72	0.08	10.62
Over all	2.43	-0.10	2.53	3.19	0.15	3.04

Again, both agricultural production and productivity seem to have grown faster during the 2000s. The area as expected showed a stagnating trend. The growth in productivity seems to be the main driver of growth in crop output (Table 5). During 1990s, the comprehensive economic reforms were initiated in India. However, the initial economic reforms did not directly influence the agricultural sector. In the late-1990s, the economic reforms intervened the agricultural sector and particularly after 2004, conscious efforts were made to increase investment and flow of credit to agriculture. These initiatives seemed to have paid off and in the post-2000 period, the growth in crop productivity accelerated.

Growth in Agricultural Productivity: Patterns across States

Across growth categories, the very low growth category had the highest number (215) of districts and the very high growth category captured the lowest number (23) of districts, thereby implying that most of the districts did not witness the growth of more than 1.5 per cent per annum in agricultural productivity (Table 6). A higher proportion of districts fell in the low growth category in states like Assam, Bihar, Kerala, Madhya Pradesh, Odisha, Uttar Pradesh and Chhattisgarh. Almost all districts in Jharkhand[2] and five districts in Gujarat registered very high growth rates. For rest of the states, the districts were unevenly distributed across different growth categories, indicating disparities in growth of agricultural productivity across the districts within a state.

Disparities in Agricultural Productivity

To study the relationship between economic growth and inequality, the Coefficient of variations, and Ginni coefficients have been used. It is interesting to note that the results of all these measures indicate similar trends. There is no considerable difference in the level of inequalities between 1990 and 2007 and it continues to persist. The persistence of same level of inequalities indicates the need for direct policy action aimed at reducing inequalities in agricultural growth. The state-wise trends depicted a mixed trend. In some of the states, the inequalities have increased over time, in some states inequalities have declined and in some of them, inequalities continue to persist at the same

[2] The growth in Jharkhand is from a very low base.

Table 6. Distribution of districts by level of growth in crop productivity across states: 1990- 2007

State	Very low	Low	Average	High	Very high	All
Andhra Pradesh	5	8	8	1	0	22
Assam	16	5	1	1	0	23
Bihar	22	4	1	2	0	29
Chhattisgarh	6	0	0	0	0	6
Gujarat	4	3	3	4	5	19
Haryana	2	6	8	0	0	16
Himachal Pradesh	7	2	1	1	1	12
Jharkhand	0	0	0	1	10	11
Karnataka	10	3	3	4	0	20
Kerala	12	2	0	0	0	14
Madhya Pradesh	23	6	9	0	0	38
Maharashtra	13	5	7	3	1	29
Odisha	13	0	0	0	0	13
Punjab	6	4	0	0	2	12
Rajasthan	9	7	5	3	3	27
Tamil Nadu	14	2	2	1	0	19
Uttar Pradesh	45	8	0	0	0	53
Uttarakhand	2	1	2	3	1	9
West Bengal	6	5	3	2	0	16
Over all	215	71	53	26	23	388

level (Table 7). The inter-districts inequalities in agricultural growth have increased over time in Bihar, Chhattisgarh, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Uttar Pradesh and Uttarakhand and have declined in Andhra Pradesh, Gujarat, Haryana, Karnataka, Kerala, Odisha, Tamil Nadu, and West Bengal. In other states like Assam, Madhya Pradesh, Maharashtra, Punjab and Rajasthan, the level of inter-district inequalities in agricultural growth remained more or less at the same level.

Regional disparities within a state can be attributed to a number of factors including diversities in the agro-climatic and socio-economic conditions. The persistence of high level of intra-state disparities in agriculture calls for more pro-active involvement of the states to promote inclusive agricultural growth.

Instability in Agricultural Productivity at District Level

The Indian agriculture is known for fluctuations and instability in its performance. The instability in productivity has a cascading effect on the farm economy and has serious implications for food-security. The estimation of instabilities at district level will be helpful in devising strategies for more vulnerable districts. The pattern of instability in crop productivity across different districts was examined and the distribution of districts based on the instability index is given in Table 8. During the period 1990-2007, the average instability index[3] across all the districts was 42.8, indicating a significant level of volatility in crop productivity. The instability categories indicate that the proportion of districts falling under very low and low productivity categories declined during 2000-07 as compared to in 1990-99, whereas, the proportion of districts falling under average, high and very high productivity categories increased. However, the average instability index during the period 1990-99 (41.3) has been found to be slightly higher than during the period 2000-07 (39.9), implying thereby that a higher level of instability in crop productivity existed within the districts in the decade of 1990s. The average instability index in very high instability category declined from 123.6 in 1990-99 to 92.0 in 2000-07, which depicts a significant fall in the instability of value of crop output per hectare across the districts.

[3] Instability index = Standard deviation of $\ln\left(\frac{x_t}{x_{t-1}}\right)\times 100$; where x_t is the crop productivity in current year, and x_{t-1} is the crop productivity in the previous year

Table 7. State-wise inter-district disparities in agricultural productivity: TE 1991–TE 2007

State	Coefficient of variation			Ginni coefficient		
	TE 1991	TE 2001	TE 2007	TE 1991	TE 2001	TE 2007
Andhra Pradesh	46.0	46.8	41.0	0.25	0.24	0.22
Assam	21.5	19.7	22.4	0.12	0.11	0.12
Bihar	19.2	26.2	27.2	0.11	0.14	0.14
Chhattisgarh	19.0	15.2	27.4	0.09	0.08	0.14
Gujarat	36.0	32.9	29.7	0.19	0.17	0.16
Haryana	45.9	39.0	42.2	0.19	0.17	0.16
Himachal Pradesh	29.1	34.7	35.2	0.15	0.19	0.18
Jammu & Kashmir	46.4	45.5	-	0.23	0.25	-
Jharkhand	45.4	34.3	60.3	0.23	0.18	0.27
Karnataka	60.3	48.9	45.7	0.27	0.23	0.23
Kerala	36.6	29.8	31.9	0.20	0.16	0.17
Madhya Pradesh	25.2	27.1	28.2	0.14	0.15	0.15
Maharashtra	52.0	52.8	56.6	0.25	0.26	0.26
Odisha	25.7	26.4	18.3	0.14	0.14	0.10
Punjab	20.0	18.8	19.5	0.11	0.10	0.11
Rajasthan	53.1	60.8	53.3	0.30	0.34	0.30
Tamil Nadu	47.2	36.6	32.7	0.24	0.20	0.18
Uttar Pradesh	23.0	23.6	27.5	0.13	0.13	0.15
Uttarakhand	30.5	52.3	52.7	0.12	0.23	0.24
West Bengal	37.9	37.1	32.7	0.21	0.2	0.17
Over all	58.3	59.8	56.9	0.30	0.33	0.29

Table 8. Distribution of districts based on instability indices and average instability index

Category	No. of districts			Instability index		
(VOP per ha NSA)	1990-2007	1990-99	2000-07	1990-2007	1990-99	2000-07
Very low (< 19%)	92(22.6)	135(33.2)	91(22.5)	14.8	13.5	13.1
Low (19-26%)	84(20.6)	72(17.7)	62(15.4)	22.2	22.4	22.8
Average (26 - 38%)	81(19.9)	71(17.4)	105(26.0)	31.2	31.9	31.6
High (38 - 58%)	78(19.2)	62(15.2)	70(17.3)	46.8	45.5	45.9
Very high (> 58%)	72(17.7)	67(16.5)	76(18.8)	107.1	123.6	92.0
Overall	407	407	404	42.8	41.3	39.9

Note: Figures within the parenthes indicate the percentage distribution of districts in each category

The state-wise distribution of districts based on instability index is given in Table 9. During 1990 to 2007, in some states more than 50 per cent of the districts were under very high instability category such as Jammu & Kashmir (100%), Jharkhand (91%) and Odisha (62%), reflecting a greater volatility in crop productivity within the districts in these states. In states like Gujarat (42%), Himachal Pradesh (42%), Kerala (43%) and Uttar Pradesh (53%), a higher proportion of districts fell in very low instability index category. In majority of the states (13), the proportion of districts falling under very low instability category declined during 2000-07 as compared to 1990-99. Only six states, namely, Assam, Jharkhand, Maharashtra, Odisha, Punjab and Rajasthan, recorded a decline in the proportion of districts falling under very high instability category during this period.

Table 9. State- wise and category-wise distribution of districts based on instability index

State	1999-99					2000-07					1990-2007				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Andhra Pradesh	11	4	4	2	1	5	5	7	4	1	5	9	5	2	1
Assam	5	7	7	2	2	9	3	9	2	0	9	3	8	2	1
Bihar	0	3	6	13	7	1	2	7	10	9	0	0	7	15	7
Chhattisgarh	1	0	3	2	1	0	1	4	1	1	0	1	1	4	1
Gujarat	8	2	4	3	2	4	5	3	1	6	8	2	2	4	3
Haryana	4	5	5	2	0	5	2	6	3	0	4	4	6	2	0
Himachal Pradesh	6	3	1	1	1	5	1	4	1	1	5	2	3	2	0
Jammu and Kashmir	1	1	0	3	9	0	0	0	0	14	0	0	0	0	14
Jharkhand	0	0	0	0	10	1	0	0	2	1	1	0	0	0	10
Karnataka	8	4	4	4	0	3	3	7	4	3	1	8	5	6	0
Kerala	11	0	3	0	0	1	4	3	5	1	6	2	4	2	0
Madhya Pradesh	15	14	3	5	1	7	11	16	4	0	10	13	10	4	1
Maharashtra	10	7	5	3	4	8	2	8	8	3	5	8	5	8	3
Odisha	0	0	0	3	10	0	0	0	5	8	0	0	0	5	8
Punjab	1	1	2	1	8	10	2	0	0	1	1	2	2	3	5
Rajasthan	2	3	5	12	6	1	2	5	7	13	1	4	1	12	10
Tamil Nadu	1	5	5	7	2	5	7	2	2	4	2	6	6	3	3
Uttar Pradesh	41	7	7	0	0	27	8	15	5	0	29	16	10	0	0
Uttarakhand	3	2	1	3	0	0	2	3	0	3	2	2	1	2	2
West Bengal	3	3	5	2	3	2	3	6	3	2	2	3	5	4	2
Over all	131	71	70	68	67	94	63	105	67	71	91	85	81	80	71

Note: 1-very low; 2-low; 3-average, 4-high; 5-very high

Trends in Use of Modern Inputs

Information on the distribution of districts based on the level of development and use of land area, labour, fertilizer, irrigation, tractors, tube-wells and access to credit from scheduled commercial banks for agriculture purposes is detailed in Table 10. The level of input-use was 4 to 5-times higher in high productivity districts than in very low productivity districts. For instance, fertilizer-use, which influences the use of other inputs like irrigation, seed, and mechanization, varied from the high of 231kg/ha in very high productivity districts to merely 33kg/ha in very low productivity districts during TE 1991. The use of fertilizers increased over time in all the categories of districts, except in very low productivity districts. These very low productivity districts had only a very small proportion of their area (17 %) under assured irrigation. More specifically, the intensity of tube-wells (No. of pumpsets/'000ha NSA) in these districts was as low as 36 against 164 in the very high productivity districts in TE 1991. Even in TE 2007 the number of pumpsets in very low productivity districts was 40 as compared to 273 in very high productivity districts. In fact, irrigation in general and assured and regulated irrigation through tube-wells in particular, along with other production efficiency enhancing machines and implements like tractors, facilitates the intensification of land use. It is evident from Table 10 that high intensity of irrigation, fertilizer, tube-wells and tractors enabled the high productivity districts to use higher proportion of their area and consequently the cropping intensity of very high productivity districts was 162 per cent in TE 2007 as compared to 114 per cent in very low productivity districts.

A perusal of Table 10 also revealed that access to credit was considerably better in the developed districts than in the low productivity districts. The institutional agricultural credit varied from ₹ 980/ha of NSA to ₹ 6022/ha in TE 2001. The credit flow increased tremendously for all the categories of districts over time. However, even in TE 2007, the institutional agricultural credit per ha of NSA was only ₹ 3280/- in the very low productivity districts as against ₹ 16409/- in very high productivity districts.

Table 10. Distribution of districts and inputs used by land productivity levels

Particulars	Period	Very low	Low	Average	High	Very high	Overall
Cropping intensity (%)	TE 1991	111	118	136	146	164	132
	TE 2001	108	125	129	144	163	133
	TE 2007	114	127	136	145	162	140
Fertilizer-use (kg/ha NSA)	TE 1991	33	53	85	107	231	85
	TE 2001	39	74	114	163	253	123
	TE 2007	33	102	126	191	251	155
No. of tractors/'000 ha of (NSA)	TE 1991	3	5	11	10	24	8
	TE 2001	7	7	11	19	21	13
	TE 2007	12	13	20	29	27	21
No. of pump sets/ ('000 ha of (NSA)	TE 1991	36	51	79	98	164	73
	TE 2001	39	70	75	124	265	102
	TE 2007	40	117	122	161	213	137
Gross irrigated area (%)	TE 1991	15.0	19.5	38.1	40.1	64.3	33.3
	TE 2001	16.5	24.2	33.5	50.6	64.2	38.8
	TE 2007	16.9	21.2	30.7	52.9	55.4	39.6
Agricultural credit/ ha of NSA	TE 2001	980	2171	2741	3908	6022	3080
	TE 2007	3258	10491	9457	15759	16409	12140
Agricultural labour/'000 ha of NSA	TE 1991	637	1073	1533	1423	1539	1223
	TE 2001	1065	1411	1609	1755	1804	1551
	TE 2007	899	2014	1945	2011	1835	1869

The availability of labour per ha of NSA was also observed to be proportional to the productivity levels of the districts. In TE 1991, the agricultural labour-use per thousand ha of NSA varied from 637 in very low productivity districts to 1539 in very high productive districts. The density of agricultural labour seemed to have increased with time. This implies that the exit of agricultural labour from the farming sector is not proportionate to its declining share in the national GDP. The intensity of agricultural labour per thousand ha of NSA at the aggregate level increased from 1223 in TE 1991 to 1869 in TE 2007. The trends in input-use clearly revealed the positive association between inputs-use and land productivity. This suggests that intensification of input-use still has the potential to enhance productivity in low productivity districts.

Determinants of Agricultural Productivity

To explore the contribution of different factors in explaining the inter-district productivity, the log form of regression was specified as follows:

$$\ln Yi_{t} = \Sigma \beta_{i} l_{n} X_{it} + V_{t}$$

where Y_t is yield in the i^{th} district in 't^{th}' year. X's are the explanatory variables for the i^{th} unit at time and β is a vector of coefficients. V_t is the residual with the usual properties.The detail specificatios of explanatory variables included in the model are as follows:

CI = Cropping intensity (%)
NPK = Fertilizer consumption (per ha of GCA)
IRR = Percentage of gross cropped area under irrigation
LIT = Rural literacy (%)
RLAB = Agricultural labour-use (per ha of NSA)
ROAD = Road density (km per '000 sq km of geographical area)
CREDIT = Agricultural credit by commercial banks (per ha of GCA)
RAIN = Average annual rainfall (mm)
TUBEWEL = Contribution of tube-wells to irrigated area (%).

The underlying hypothesis in this model is that intensive use of land, labour, fertilizers, tractors, institutional credit, and irrigation leads to higher agricultural productivity. The model also hypothesizes that a higher proportion of area under high-value crops contributes to higher productivity. It is also hypothesized that availability of better human resources capital of the workforce enhances its capacity in terms of performance of work, awareness about technology and efficient utilization of inputs and services. All these tend to augment agricultural productivity. The impact of weather conditions on agricultural productivity has also been incorporated in the model by inserting the average rainfall in each district.

The cross-sectional time-series method of regression was used. It incorporates the cross-sectional effect of independent variables on agricultural productivity as well as the time-series effect within districts. The critical assumption of this cross-sectional time series model is the 'pooling', that is all units are characterized by the same regression equation at all points of time. Whether the fixed or random effects model should be used is both a substantial and a statistical question. The Haussmann specification test was conducted to choose the appropriate model. The Haussmann test supported the estimation of fixed effects model. Accordingly, fixed effects model was estimated and the results of the same are summarized in Table 11. The estimated values of all the coefficients had expected signs and all of them were found significant. The elasticity of cropping intensity was observed to be as high as 1.17, followed by fertilizer-use (0.29), irrigation (0.20), literacy (0.19), rainfall (0.17), road density (0.11) and credit (0.0003).

The use of fertilizers has been found to be the most important factor to explain the difference in the levels of agricultural productivity across districts. Along with fertilizer-use, irrigation, source of irrigation, better human resources and road connectivity have emerged as the critical determinants of agricultural productivity across districts. Besides, good rainfall has also been observed to have a significant and positive influence on the agricultural productivity, reiterating the importance of weather on agricultural production. It may be mentioned that barely 40 per cent of the gross irrigated area is irrigated in India and even though its increase contributes significantly to the agricultural productivity growth, rainfall continues to be a crucial factor in determining agricultural productivity. In fact, irrigation is also directly or indirectly dependent on rainfall. The number of pump sets, representing the quality and assurance of irrigation, was found to have a positive influence on agricultural productivity. The role of agricultural credit, though significant, was not observed to be high. It could be attributed to the fact that the access to institutional credit induces the farmers to higher adoption of improved seeds, increased fertilizer-use and irrigation and its influence could be included in the impact of these inputs.

Table 11. Determinants of agricultural productivity

Explanatory variable	Coefficient	Standard error
CI	1.175211***	0.118285
NPK	0.292095***	0.026719
IRR	0.196151***	0.325344
LIT	0.192232**	0.080177
RLAB	-0.125430***	0.032180
TUBEWELL	0.075817***	0.016441
ROAD	0.109811***	0.029012
CREDIT)	0.000003**	0.0000015
RAIN	0.167709***	0.032143
Constant	0.434599	0.611972
R^2	0.7114	

Conclusions and Policy Implications

Since macro trends in agricultural production in a country like India do not reveal the real picture at grass root level, the present study has been carried at the district level. It will facilitate pragmatic agricultural development planning and policy formulation at lower administrative units. The study has examined the trends in productivity of crop sector at district level. The study has also highlighted the instabilities in growth of productivity across districts and has identified the important factors for varied performance across districts.

The productivity of crop sector has shown wide variations across districts both for the country as a whole and within a state. The varying performance of crop sector at district level has indicated the need for evolving specific strategies at district level for ensuring sustainable and inclusive agricultural growth in a state consequently in the country. Cross classification of districts helped in understanding the linkage between agricultural productivity and their determining factors.

The districts have depicted very low and low productivity having low rainfall and less irrigation facilities, resulting in lesser use of modern inputs. The instability in productivity continues to persist and there are wide variations in instability across different districts in a state. To mitigate the consequences of persisting instability, large-scale promotion of stabilization measures like insurance should be vigorously pursued.

The analysis of district level data has further revealed the important role of modern inputs in enhancing the productivity of crop sector. Use of fertilizer has turned out to be the most important input. Along with fertilizer-use, irrigation, source of irrigation, better human resources and road connectivity have emerged as other critical determinants for agricultural productivity. Besides, good rainfall has also been observed to have a significant and positive influence on the agricultural productivity. These results have signified the importance of use of modern inputs and prudent management of rainfall water, particularly in the low productivity districts.

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