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Foodgrain production performance in Bihar: A temporal analysis

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ABSTRACT

The paper presents the growth in foodgrain production in different agro-climatic zones of Bihar during the last 30 years (1984 to 2014). There has been growth in production of foodgrains during the period under study, however, maize and wheat recorded the steady growth during the period. Pulses production got setback in all the agro-climatic zones, particularly during 1984-94. Agro-climatic zone II had an edge over other three agro-climatic zones with respect to increase in foodgrain production mainly due to lower foodgrain production during the base year (TE 1984). Foodgrain production got a boost during 2004-14. Instability in production of all foodgrains was high, but higher instability in production was observed in rice and lower in wheat.The instability in foodgrain production was mainly due to frequent floods in north Bihar and droughts in south Bihar. Also, the growth and instability had positive relationship across all the zones. However, the sustainable increase in foodgrain production was made possible due to improved farmers' access to inputs and technology. All the three critical inputs (irrigation, fertilizers and HYV seeds) played a significant role in increasing foodgrain production in Bihar.

Key words: Bihar, Foodgrain, Instability, Production, Productivity

Agriculture is an important sector for Indian economy and it provides employment to more than 50% of our workforce. This sector has performed impressively in terms of increased productivity and intensity of cultivation. The per capita availability of foodgrain at country level (465 g/day) has been almost stagnant over the last three decades despite the assault of population pressure, declining per capita land availability and unfavorable weather (GOI 2016). An important dimension of agricultural growth is the spatial and temporal variations which is very relevant in a large country like India having a wide range of crop-soil-weather conditions. The scenario of agricultural growth is quite different for Bihar as many times it faces weather menace of drought and flood simultaneously, which creates a challenging situation for agricultural development.

Bihar offers rich fertile land, which is mainly flat and around two-third of its area is arable. With a population of about 104 million, it is the third most populated state in India and supports about 9% of population with only 2.9% of land mass of the country. Bihar also has the distinction of being the most densely populated state of the country (1102 persons/sq km) as against the national average of 382 persons/sq km. The state continues to be among the economically most backward ones with one of the lowest per capita income (36% of national per capita income) and the highest incidence of poverty (34%) in the country. However, during the last six years the growth rate of State's GDP has considerably accelerated, with the state economy growing at over 10% /annum (GoB 2016). Even then, prevalence of under and malnutrition along with high mortality among children is witnessed in the state.

The structure of economy in Bihar has undergone a sea change overtime, however, the importance of agriculture continues to be significant. It contributes about 19% to Net State Domestic Product and provides employment to 67% of rural workforce. Agricultural households constitute about 51% of rural households, dominated by marginal and small land holder farms with marginal farms (< 1 ha) comprising 91% of total farm households and owning about 57% of the operated land in Bihar. The continuance of farmers with declining resource base would require more intensive crop production with robust growth and stability in the sector for ensuring food security and improvement in their livelihood in Bihar.

Most of the studies in the field of growth and instability of foodgrain production are based on national and state level data. Rainfall, irrigation, and agro-physical situations are important factors influencing instability in foodgrain

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production in India (Ray 1983, Mahendradev 1987, Rao *et al.* 1988). These factors in different agro-ecological regions vary much even within the state. Therefore, regional studies with different sub-periods would generate more meaningful information on these important aspects of agricultural development. The present study was, therefore, undertaken to analyze the nature and extent of growth in foodgrain production in Bihar during last 3 decades.

MATERIALS AND METHODS

The present study was based on secondary data obtained from published documents and reports of Government of Bihar. Data were analyzed by computing data for different agro-climatic zones. There were substantial variations in year to year agricultural data due to influence of abiotic and biotic constraints to crop production. Hence, data were made smooth by estimating series of triennium (three years average) data for area, production and productivity of principal crops.

Data of area, production and productivity of principal foodgrain crops namely, rice, wheat, maize and pulses were analyzed for the last 30 years, from 1984 to 2014. The year of TE 1984 was considered as base because foodgrain productivity of some region just crossed one tonne/ha. Data were also analyzed and presented for all the four agro-climatic zones of Bihar, i.e. northern west agro-climatic zone (Zone I), northern east agro-climatic zone (Zone II), southern east agro-climatic zone (Zone III A) and southern west agro-climatic zone (Zone III B).

In order to find out the compound growth rates of area, production and productivity of important crops, following exponential function was used:

$$Y_t = AB^t$$

where, Y_t = area/production/productivity of concerned crop in the year, A = intercept, t = year. B = 1+r/100.

Percentage rate of compound growth per annum was calculated as:

$$r = (B - 1) \times 100 \text{ or } (\text{antilog } B - 1)$$

which represents a rate of change from observation to observation during the period under study.

To analyze the fluctuations in area, production and productivity of principal foodgrain crops, standard deviations (SD) were estimated for the study period. Of the various measures of absolute dispersion, the standard deviation has been used in various studies because it is most suitable for measuring deviations in time series data (Croxton *et al.* 1975).The greater value of co-efficient of variation indicates more instability. Variability in annual output growth rates provides a measure of the degree of instability in production over the specified period. Moreover, decomposition of the variability in annual output growth rates may help to identify the sources of change in instability in production over different periods. Besides the institutional, technological, economic and weather factors, the quantifiable and most closely associated factors like area, productivity and their interaction are likely to influence instability in agricultural production. The variability in annual output growth rates over a specified period of length 'T' can be decomposed as:

$$V(G_o) = V(G_a) + V(G_y) + 2\,Cov(G_a G_y)$$

where G_a, G_y and G_o are growth rates in area, yield and output estimated over the period under study.

To identify determinants of foodgrain output, the following form of function was used:

$$Y' = B'_0 + B'_1X_1 + B'_2X_2 + B'_3X_3 + B'_4X_4 + B'_5X_5 + u$$

$$\text{Log } Y' = \text{Log } B'_0 + B'_1 \log X_1 + B'_2 \log X_2 + B'_3 \log X_3 + B'_4 \log X_4 + B'_5 \log X_5 + \log u$$

where, Y = annual production of foodgrains (in tonnes), X_1 = gross cropped area (in ha), X_2 = gross irrigated area (in ha), X_3 = fertilizer consumption (in tonnes), X_4 = HYV area (in ha), X_5 = annual rainfall (in mm).

RESULTS AND DISCUSSION

Decadal scenario

Modern agricultural technology has influenced the crop-mix across the country, which is more prominent in Bihar. During the post-Green Revolution period a decline in area under rice, millets and pulses; and an increase in area under wheat and maize were observed in Bihar (Singh and Ranjan 1998). In this paper, an attempt has been made to examine the changes in area, production and productivity of principal foodgrain crops at four points of time that is; 1984, 1994, 2004 and 2014. Rice, wheat, maize and pulses are the principal foodgrain crops of Bihar, which constitute about 82% of gross cropped area (GCA) and 99% of area under foodgrain crops. Area under foodgrain crops showed mix trend but fluctuated between 64 to 69 lakh ha, mainly due to decline in area under pulses during the period under study, whereas area under cereals increased from 57 lakh ha at TE 1984 to 61 lakh ha at TE 2014 with minor fluctuations (Table 1).

Bihar has a cereal dominated cropping pattern. The GCA of cereals increased from nearly 71% during TE 1984 to 77% in TE 2014. Rice, the most important staple food crop, is grown in all the agro-climatic zones of the state. Though there was decline in area under rice, it contributed significantly to the foodgrain production. The area under rice varied between 32 to 34 lakh ha during last 30 years and constituted more than 40% to GCA of the state (Kumar *et al.* 2018).The maximum decline (from 14.12 lakh ha in 1984 to 12.58 lakh ha in 2014) was observed in Zone I. Wheat was the only crop which recorded steady growth in area during the period under study and emerged as the second important staple food crop in Bihar. Maize is the third important cereal crop in the cropping pattern in Bihar and is grown in all the three crop seasons. Maize was grown mainly in *kharif* season till 1970 but farmers are now reluctant to grow *kharif* maize, resulting in decline in area under *kharif* maize. But total area under maize increased

Table 1 Area, production and productivity along with compound annual growth rates (CAGR) of principal crops in Bihar during 1984-2014

Crop categories	TE 1984	TE 1994	TE 2004	TE 2014	1984-94	1994-2004	2004-14	1984-2014
	Area (Lakh ha)				*CAGR (Per cent)*			
Rice	33.64	32.52	34.34	32.28	-1.23	-0.26	-0.23	-0.52
Wheat	17.64	19.65	20.78	21.70	1.04	0.91	0.67	0.55
Maize	6.15	5.96	6.06	7.11	1.02	-0.09	2.01	0.72
Pulses	10.01	5.62	6.75	5.00	-10.30	-1.36	-2.53	2.10
Foodgrains	68.67	64.33	68.93	66.65	-1.28	0.07	0.09	-0.33
	Production (Lakh tonnes)				*CAGR (Per cent)*			
Rice	31.89	39.32	42.68	67.78	-1.19	0.44	8.01	0.75
Wheat	26.97	39.04	36.59	52.86	3.58	0.11	5.02	1.79
Maize	8.17	11.71	14.44	27.13	5.19	2.07	8.26	3.98
Pulses	6.86	4.41	5.25	4.82	-9.48	-0.18	0.78	-1.46
Foodgrains	91.40	94.50	100.84	153.49	0.73	0.69	6.76	1.36
	Productivity (kg/ha)				*CAGR (Per cent)*			
Rice	948	1209	1243	2100	0.04	0.70	8.25	1.28
Wheat	1529	1987	1761	2436	2.51	-0.80	4.32	1.23
Maize	1329	1964	2383	3816	4.13	2.17	6.13	3.24
Pulses	686	785	778	965	0.92	1.19	3.39	0.66
Foodgrains	1331	1469	1463	2303	2.04	0.62	6.67	1.70

from 6 lakh ha to 7 lakh ha during the period under study. The increase was much higher in Zone II (116%), whereas it remained almost constant in Zone I and declined in Zone IIIA and IIIB. Dynamics of maize area scenario depends on pace of replacement of *kharif* maize by winter maize. Adoption of winter maize was at large scale in Zone II, whereas the process of the replacement was slow in Zone IIIA and IIIB and moderate in Zone I during the period.

Pulses are the next important crop in Bihar. But area under pulses declined by 50% during the period under investigation. The breakthrough via high-yielding varieties (HYVs) in cereals has been accompanied by a loss of acreage under pulses to cereals, and consequently a sharp decline in the total production of pulses. Moreover, there has been no breakthrough in the productivity of pulses, nor enough effort has been made to achieve it and spread it through extension work up to 2014 due to which an increase in productivity could not compensate the loss of area and pulses production declined from 6.86 lakh tonnes at TE 1984 to 4.82 lakh tonnes at TE 2014. However, the Government has taken a number of initiatives during last two years for increasing pulses production in Bihar also.

Zone wise CAGR in production of foodgrains revealed an increase in foodgrain production during study period in all the four agro-climatic zones of Bihar, however, pulses observed declining trend in production (Table 2).

During 1984-94, rice and pulses production showed negative growth in all the agro-climatic zones, but foodgrain production rates were positive in Zone I and Zone II and negative in Zone IIIA and Zone IIIB. In Zone I and Zone II, loss in production of rice and pulses were compensated

Table 2 Zone-wise CAGR of production of principal foodgrains in Bihar during 1984-2014

Crop	Study period (1984-2014)	Sub study periods		
		1984-94	1994-2004	2004-14
		Zone I		
Foodgrains	0.80	1.59	-0.33	5.62
Rice	1.04	-1.64	0.49	7.95
Wheat	1.84	4.91	-0.15	3.75
Maize	1.55	4.74	-0.80	5.19
Pulses	-2.56	-8.83	-1.38	0.60
		Zone II		
Foodgrains	2.25	1.53	3.37	3.26
Rice	2.25	-0.40	1.65	8.83
Wheat	1.37	4.34	-0.33	6.22
Maize	7.09	5.08	10.19	12.45
Pulses	-0.93	-8.90	2.09	-2.69
		Zone III A		
Foodgrains	1.77	-0.54	0.83	4.33
Rice	1.40	-3.07	1.32	9.43
Wheat	2.63	0.39	0.95	4.99
Maize	5.36	9.24	-2.63	4.32
Pulses	-0.43	-6.25	1.62	-1.49
		Zone III B		
Foodgrains	1.44	-0.30	0.22	8.51
Rice	1.30	-0.81	0.02	10.36
Wheat	1.75	2.19	0.43	5.95
Maize	2.15	2.32	-0.73	4.46
Pulses	-1.34	-11.70	-0.63	3.24

by increase in production of wheat and maize, whereas increase in these two crops could not compensate the loss of rice and pulses production in Zone IIIA and Zone IIIB, resulting in negative growth rate. Besides, there was moderate to severe flood in most of the districts of Bihar during the period 1984–1994, which adversely affected the foodgrain production.

The period of 1994-2004 was the worst period for agricultural production in Bihar when per hectare foodgrain productivity was almost stagnant. Moreover, it declined from 1469 kg at TE 1994 to 1463 kg at TE 2004.Wheat has been the most promising crop of Bihar during period of study and its production got doubled during 1984–2014, but the lowest growth in wheat production in all the agro-climatic zones of Bihar was also observed during 1994-2004. Maize, another promising crop of the state, achieved record increase in production, but its production growth rate was negative during 1994-2004 in all the zones except Zone II, which recorded positive growth rate because of introduction of winter maize in this zone. The unsatisfactory growth in foodgrain production during 1994-2004 was mainly due to less increase in irrigated area (44% to 48%), slow growth in fertilizer consumption (98 kg/ha) and negligible increase in seed replacement rate of principal crops.

Foodgrain production experienced spectacular growth during 2004-2014. All the three principal foodgrain crops achieved positive growth in all the agro-climatic zones. There was more than 9.0% annual growth in rice production in Zone III A and III B during the period. Rice was the only crop which recorded increasing growth rate across the study period in all the zones. Maize production grew by 12.45% annually in Zone II, mainly due to increase in area under winter maize from 79 thousand ha in 2003-04 to 112 thousand ha in 2013-14. Pulses production also had positive growth in Zone I and Zone IIIB. The higher growth in foodgrain production during 2004-2014 was mainly due to increase in irrigated area (from 48.5% to 64%), increase in fertilizer consumption (121 kg/ha to 161 kg/ha) and achievement of almost recommended seed replacement rate in principal crops namely; rice (39%), wheat (36%), and maize (85%). Moreover, the state government assigned priority to the agricultural sector through increasing annual average budget allocation from less than ₹ 2000 million during 2001-05 to more than ₹ 34282 million during 2011-15. The formulation of strategy for agricultural development through preparing Agriculture Road Map document from Sixth Five Year Plan (FYP) might have improved the agricultural development process during the last 10 years in Bihar.

Instability in production

In order to examine the fluctuations in output of foodgrain production, annual changes in output of principal foodgrain crops and their standard deviations (SD) were estimated for the study period and all the three specified sub–periods. Analysis of instability (variation) with respect to foodgrain production showed variations ranging from 20 percent in Zone I to 27.6 percent in Zone IIIA. Zone I had the lowest growth and the lowest instability in foodgrain production, whereas Zone II had the highest growth and the highest instability (Tables 2 and 3). Comparatively high fluctuation and growth in output was observed in case of maize in Zone II (69.8%) and the lowest in Zone I (21.8% and 1.55%). But it showed declining trend due to adoption of scientific method of winter maize production. However, instability in production of all principal crops declined from 1984-94 to 1994-2004 in all the zones, except rice and maize in case of Zone II, whereas there was reverse trend in succeeding period when instability in all the foodgrain crops increased from the period 1994-2004 to 2004-2014 and growth in output of all foodgrain crops also increased in all the zones, except pulses in Zone II and IIIA. Hence,it may be said that growth and instability have positive relationship in crop production. Rice output was observed to have increasing instability in three zones, except in Zone I, but growth in rice output also showed increasing trend across the three sub-periods in all the zones. The production of individual crops and total foodgrain crops had increasing growth, but

Table 3 Instability in production of principal foodgrain crops in Bihar during the study period along with sub-periods

Crop	Study period (1984-2014)	Sub- period		
		1984-1994	1994-2004	2004-2014
		Zone I		
Foodgrains	20.0	13.6	9.6	27.9
Rice	26.9	20.8	10.4	35.5
Wheat	27.1	16.8	12.2	29.0
Maize	21.8	20.4	11.0	22.2
Pulses	33.8	29.6	13.2	15.9
		Zone II		
Foodgrains	27.7	13.7	13.5	25.4
Rice	32.3	20.2	21.5	32.3
Wheat	25.9	18.2	12.4	32.2
Maize	69.8	20.3	29.2	42.8
Pulses	25.8	30.4	10.4	30.1
		Zone III A		
Foodgrains	27.4	15.3	16.8	27.0
Rice	42.6	29.5	40.5	43.0
Wheat	31.1	15.9	12.1	26.3
Maize	51.6	43.8	36.8	26.6
Pulses	25.3	27.9	13.6	30.0
		Zone III B		
Foodgrains	25.9	13.4	18.0	33.3
Rice	34.5	18.0	23.8	43.6
Wheat	21.5	11.4	6.6	22.6
Maize	32.9	26.1	20.6	30.6
Pulses	29.1	33.5	10.2	13.7

became more instable during 2004-14 as compared to the earlier periods.

Bihar's agriculture achieved a spectacular growth in crop output during 2004-14 and production instability might be an inevitable consequence of rapid agricultural growth but at national level the spread of improved technology is found to be associated with decline in variability in production during 1968-2006 (Chand and Raju 2009). However, it does not stand true in case of Bihar where adoption process of new technology of crop production had been slow up to the mid tenth FYP. Moreover, deficient rainfall in 5 years out of 10 years of 2004-14 might have attributed to increase in production instability in foodgrain crops in Bihar.

The changes in the variability of yields of individual crops within states have been an important contribution to the increase in the coefficient of variation of cereal production (Hazell 1982). Ranjan (2000) while analyzing growth and instability in foodgrain production found that area and yield generally move in same direction in Bihar, but area instability is generally lower than the yield instability for almost all principal crops. The variability in annual output is decomposed into variability in area, variability in yield and synchronous movement in area and yield. It has been observed that the yield variability has been the major factor for instability in production of wheat and pulses. Foggy weather condition and terminal heat stress adversely affect the wheat productivity.The foggy days decrease the penetration of sunlight to the wheat crop; and heat stress, especially at the terminal stage is seen as a major reason for declining yield (Nagarajan 2005, Joshi *et al.* 2007). In Bihar, late sown wheat is adversely affected by terminal heat and foggy weather which spreads to 15 to 20 days during wheat crop season. Pulses are hardier than most crops and help to nourish the soil. But the beneficial effects of CO_2 enrichment in pulses is largely nullified by abrupt increase in temperature due to global warming which is often detrimental to crop growth and grain yield (Singh 2010). It seems to be one of the reasons of contribution of yield variability to production variability in pulses production.

The contribution of residual factor (interaction area × yield) was substantial (67.01%) in rice production, indicating that a large contribution to instability in rice production in Bihar. Rice area has been moved between 32 to 34 lakh ha, whereas per ha rice productivity was almost stagnant at around 12 q during 1994-2004. Hence, variability in these two factors has been at low level and did not affect much to production variability. Moreover, aberration in rainfall, frequent flood and drought, waterlogging and unorganized marketing might be reasons for variation in rice production in Bihar. Area and yield of winter maize showed increasing trend, hence their variability contributed substantially to production variability and there was less impact of residual factor on production variability.

Table 4 Decomposition of instability in annual output growth rate during 1984-2014

Crop	Area	Yield	Residual
Rice	12.93	20.06	67.01
Wheat	9.49	90.48	0.03
Maize	40.67	58.62	0.71
Pulses	1.65	98.32	0.03

Determinants of foodgrain production

There are various factors influencing foodgrain production which differ regionally and from year to year also. Many attempts were made earlier to study the determinants of foodgrain production but most of them were conducted at national level (Joshi *et al.* 2004). Despite the preciseness in analysis, the findings of studies conducted at national level may not be valid for a region having a typical agro-climatic situation like Bihar. In the present analysis, the usually employed production function of Cobb – Douglas type model was adopted to the time series data from 1984 to 2014.In this model, annual foodgrain production was considered as dependent variable and five explanatory variables such as gross cropped area, irrigated area, fertilizer consumption, coverage under HYV seeds and annual rainfall as independent variables.

All the five variables included in the study jointly explained about 90% ($R^2 = 0.9038$) variation in foodgrain production in Bihar (Table 5). The remaining unexplained variations were mainly due to factors which were not included in the model either due to unavailability of time series data or the problem in quantification of variables. The coefficient of all the three critical inputs; irrigated area, fertilizer consumption and area under HYV seeds were found to be positive and statistically highly significant, indicating that these variables played an important role in increasing food grain production in Bihar (FAO 2006, Ali 2006, Stewart and Robert 2012). The coefficient of GCA is comparatively high (0.3108) and statistically significant, indicating that land area is still playing an important role in foodgrain output in Bihar. The coefficient of rainfall was negative (-0.1146) but it was not significant at even 10 per cent of probability. It was probably because of typical land situation of north Bihar and recurrent floods caused by heavy rainfall. Rainfall above the normal level would

Table 5 Regression coefficient and corresponding standard error of different variables contributing foodgrain production in Bihar during 1984-2014

Independent variables	Coefficients	Standard error	t value	Probability
Gross cropped area	0.3108	0.0710	4.38	0.00
Goss irrigated area	0.2835	0.0675	4.20	0.00
Area under HYV	0.2191	0.0508	4.32	0.00
Fertilizer consumption	0.2186	0.03925	5.57	0.00
Annual rainfall	-0.1146	0.0726	-1.58	0.12
Constant	0.1992	0.6357	0.31	0.75

R^2= 0.9038, Number of observations- 116

adversely affect the foodgrain output. Moreover, spectacular increase in irrigated area (62%) tends to nullify the prime importance of irrigation.

In Bihar, rice, wheat, maize and pulses are principal crops and jointly constitute about 82% of gross cropped area, but area under foodgrains declined during last 30 years. The decline in pulses area was more pronounced, particularly during 1984-94 due to shift of pulses area to wheat crop. It was mainly due to increase in irrigated area on the one hand, and various types of risks in pulses production on the other, resulting into unfavourable economics of its production. However, wheat and maize recorded steady growth in area during period under study. Rice also faced a setback in area expansion during the period under study. Despite decline in area under foodgrains, production observed increasing trend due to substantial increase in production of maize and wheat, which was made possible due to increase in area and productivity of these two crops in Bihar. Productivity of all foodgrain crops including pulses increased during all the three specified periods. However, maize productivity recorded the highest growth due to introduction of winter maize. Foodgrain production could achieve less than 1 per cent increase in 1984-94 and 1994-2004, but recorded production growth of 6.76% during 2004-14. Productivity growth contributed significantly to production of all foodgrain crops in all agro-climatic zones. Hence, it may be concluded that the pace of growth in foodgrain production really got a boost during middle of the last decade in Bihar.

Agro-climatic zone II performed better across the four zones during last 30 years of Bihar because the zone was late starter in adoption of modern agricultural technology. The productivity of foodgrain was the lowest (less than one tonne) among climatic zones of Bihar in early eighties. Zone II had edge over other three agro-climatic zones with respect to increase in production of maize and rice, mainly due to large scale adoption of winter maize and adoption of modern technology in rice production. However, foodgrain growth performance in different zones indicated that Zone III B performed much better in increasing foodgrain production during 2004-14 due to improved infrastructure and rich base of agricultural development.

The instability in foodgrain production was mainly due to frequent floods in north Bihar and drought in south Bihar. These natural calamities occur simultaneously in Bihar. However, the growth and instability had positive relationship across zones of Bihar. The contribution of residual factor was found substantial (67.01%) in rice production, whereas in maize production, area and yield showed increasing trend and their variability contributed substantially to production variability.

There are various factors affecting the foodgrain production but all the three critical inputs; irrigation, fertilizers and area under HYV seeds are found playing significant role in increasing foodgrain production in Bihar. Land area is still playing an important role in foodgrain production because potential of scarce land is yet to be exploited in Bihar. Launch of mega projects namely; National Food Security Mission (NFSM), Rashtriya Krishi Yojana (RKY) and Bringing Green Revolution in Eastern India (BGREI) facilitated farmers' access to inputs, farm machineries and technology which helped in increasing food grain production in Bihar. Similar agricultural development projects should be in place in future also for increasing foodgrain production in Bihar.

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