Growth and Instability in Rice production: A District Level Analysis of Bihar and Jharkhand States of India

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Abstract

Bihar and Jharkhand are the most important states in Eastern India in terms of rice production. It is essential to study the growth pattern of rice production in these states. Therefore the present study was conducted to examine the growth rate and instability in area, production and yield of rice in Bihar including Jharkhand state. The data was collected for the period 1980-81 to 2019-20 and divided into five periods for analysis. Compound annual growth rate and Cuddy-Della Valle Instability index have been computed for the five periods. The new approach has been proposed for classification of instability values under five classes. Highest growth rate for area and production was observed in Hazaribag district during period IV and for yield it was recorded in Begusarai district during the same period. During period I and II most of the districts recorded positive growth rate for production and yield. The instability varies from 2.76 to 99.62 percent for area, 13.24 to 119.98 percent for production and 9.34 to 173.28 percent for yield across the districts during five periods. For production and yield, most of the districts recorded medium instability during period I and period II; and high instability during period III, period IV and period V.

Keywords: Rice, Production, Growth rate, Instability, Bihar, Jharkhand

1. Introduction

Rice is the staple food for about half of the world population and more than two thirds of the Indian population. India ranks first in rice area and second in rice production next to China. In India, rice is grown in more than 45 million hectare area with the production of 124 million tons of milled rice in 2020-21 contributing approximately 23% of the global rice production. Rice cultivation engages the most of the workforce in the economy as the source of livelihood for those people. Rice accounts for 40% of the total food grain production occupying 35% of the food grain area of the country. Bihar and Jharkhand are most important states in Eastern India in terms of rice production. Both states jointly produced 9.31 million tons of rice in 4.24 million hectare area with an average yield of 2.19 tons per hectare. They both contribute 7.8% of the countries rice production in 9.7% of the rice area.

For higher growth of agriculture, quantitative assessment of the contribution of different factors of agricultural output growth is important for reorienting the programmes and prioritizing the

agricultural development. Various factors affect the growth of agricultural output. Major ones of these factors are area and yield. (Singh, 1981; Cauvey, 1991). These major sources of output growth have significance in finalizing programmes of agricultural development and priorities of investment in it (Ranade, 1980; Deosthali and Chandrashekhar, 2004). Hence, it may be vital to find why the growth rates different from one another, so as to remove the bottlenecks to achieve the fast development of agricultural sector (Sikka and Vaidya, 1985). The study of instability is also required to find out the fluctuation in the trend for area, production and yield of rice which is severely affecting the production, and indirectly employment and income distribution there by hampers the economic growth of the state. District wise growth rate and instability in rice have been computed by researchers for some states (Jambhulkar et al, 2020; Jambhulkar et al, 2021; Akula et al, 2022; Jambhulkar et al, 2023) but could not able to trace the district wise study for Bihar (including Jharkhand) state.

Keeping in view, the present study is undertaken to examine district wise growth rate and instability in area, production and yield of rice in Bihar (including Jharkhand) state.

2. Material and Methods

The present study is undertaken based on secondary rice data of Bihar (including Jharkhand) state from 1980-81 to 2019-20. The district wise data on area, production and yield of rice have been collected from Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India during different time periods in the last ten years. Last forty years data since 1980-81 have been used for the study. Jharkhand state was a part of Bihar and separated from Bihar in 2000. Hence, the study was carried out for all the districts of Bihar and Jharkhand. There were thirty districts during 1980s in the undivided Bihar state. Many districts were carved out and separated as a new district during the decades 1990s, 2000s and 2010s. All the major rice growing sixty two districts of Bihar (including Jharkhand) were combined into thirty seven districts. For lucidity, the forty years data (1980-81 to 2019-20) is divided into five periods. Period I (1980-81 to 1989-90), period II (1989-90 to 1999-2000), period III (2000-01 to 2009-10), period IV (2010-11 to 2019-20) and the overall period as a period V (1980-81 to 2019-20).

The growth rate of area, production and yield for districts of Bihar (including Jharkhand) state for each period is computed to study the growth pattern in area, production and yield of these districts.

Compound growth rate was estimated using following exponential model (Dandekar, 1980).

$$Y = ab^t$$

$$\text{Log } Y = \log a + t \log b$$

$$\text{CGR(r)} = [\text{Antilog (log b) -1}] \times 100$$

where,

CGR = Compound growth rate

t = time period in year

Y = area/ production / productivity

a and b = Regression parameters

The performance of agricultural output affected by climatic factors, the growth rate has been calculated based on three years average data (Minhas, 1966; Dandekar, 1980; Singh and Rai, 1997).

Instability means deviation from the trend. In agriculture, instability is an inherent characteristic due to weather conditions, seasonal variation in area, yields and production of crops from year to year. The instability in area, production and yield of rice is computed to measure the variability

using an index of instability called Cuddy-Della Valle index (Cuddy and Della Valle, 1978). This method is used to examine the extent of risk involved in crop production.

The instability in area, production and yield was estimated using the following Cuddy-Della Valle Index.

$$CDVI = CV \times \sqrt{(1 - Adj.R^2)}$$

where,

CDVI = Cuddy-Della Valle Instability index (per cent)

CV= Coefficient of variation (per cent)

Adj. R^2= Coefficient of determination from a time trend regression adjusted by the number of degree of freedom

The authors proposed the classification of instability into five classes as follows:

Class	**Range of instability**
Very low instability	0 to 5
Low instability	5 to 15
Medium instability	15 to 30
High instability	30 to 50
Very high instability	> 50

3. Results and Discussion

The rice area in Bihar (including Jharkhand) was decreased from 5.46 million hectare in 1980-81 to 4.24 million hectare in 2019-20. The rice production was increased from 5.64 million tons in 1980-81 to 9.31 million tons in 2019-20. Rice yield was increased from 1.03 t/ha in 1980-81 to 2.19 t/ha in 2019-20. Therefore, during last forty years rice area was decreased but rice production and yield was increased 1.65 and 2.15 times respectively (Figure 1). Hence, it is vital to study the trend of area, production and yield of rice in Bihar (including Jharkhand).

3.1 Compound Annual Growth Rate

The district-wise compound annual growth rate for area, production and yield of rice in Bihar (including Jharkhand) state have been given in Table 1. Analysis across the districts revealed that the growth rates of area, production and yield of rice are varying across various studied periods.

During period I (1980-81 to 1989-90), the highest growth rate for area (2.94%) and production (10.03%) was observed in Siwan while the highest growth rate for yield (3.64%) was recorded in Aurangabad. Lowest growth rate for production and yield was observed in Samastipur whereas lowest growth rate in area was recorded in Gaya district. In this period most of the districts recorded positive growth rate for production and yield.

During period II (1990-91 to 1999-2000), East Singbhum district recorded highest growth rate in area (6.15%) and production (12.08%) however yield growth rate (9.67%) was highest in Patna district. Lowest growth rate for area was observed in Patna and for production and yield was recorded in Darbhanga district. In this period, negative growth rate for yield and production was observed in two and four districts respectively.

During period III (2000-01 to 2009-10), highest growth rate for production (8.92%) and yield (11.69%) was recorded in Lohardaga while lowest growth rate in area (1.57%) was observed in Muzzafarpur district. Lowest growth rate for area, production and yield was observed in Dhanbad, Patna and Gopalganj respectively. In this period, the growth rate for area, production and yield was negative for most of the districts.

During period IV (2010-11 to 2019-20), Hazaribag recorded highest growth rate in area (12.45%) and production (22.31%) however highest growth rate in yield (14.71%) was observed in Begusarai district. Lowest growth rate for area, production and yield was observed in Begusarai, Gopalganj and West Champaran districts respectively. In this period, the growth rate for yield was positive for all the districts. Growth rate for production was positive for most of the districts. Similar trend was observed in Odisha (Jambhulkar et al, 2020).
During overall period V (1980-81 to 1919-20), highest growth rate for production (3.64%) and yield (3.07%) was recorded in Aurangabad while Saharsa recorded highest growth rate for area (1.07%). Lowest growth rate for area and production was observed in Godda district and Sahibganj recorded lowest growth rate for yield. In this period, growth rate for yield was positive for all the districts. Similar trend was observed in Punjab (Jambhulkar et al, 2021) and Telangana (Akula et al, 2022). Growth rate for production positive for all the districts except five and for area it was negative for most of the districts.
Highest growth rate for area and production was recorded in Hazaribag district during period IV and for yield it was recorded in Begusarai district during the same period.

3.2 Cuddy-Della Valle Instability Index

The level of instability cannot be detected by focusing solely on growth rates. Growth rate will simply explain the rate of growth over time, whereas instability will determine whether the growth performance for the variable under study was stable or unstable over time. In this study, the level of instability in the area, production and yield of rice was determined by using Cuddy-Della Valle Index.
The Cuddy-Della Valle Index for area, production and yield of rice has been presented in Table 2. During period I (1980-81 to 1989-90), highest instability for area (24.49), production (46.03) and yield (36.08) was found in Nalanda, Begusarai and Samastipur districts respectively; whereas the lowest instability was recorded in East Champaran district.
During period II (1990-91 to 1999-2000), highest instability for area (34.44) and yield (173.28) was recorded in Patna while highest instability of production (53.62) was observed in Begusarai district. Lowest instability for area (5.61), production (13.38) and yield (11.01) was observed in Gopalganj, Dumka and West Champaran district.
During period III (2000-01 to 2009-10), the highest instability for area and production was recorded in Sahibganj and lowest instability in yield was observed in Palamu district. Lowest instability for production (13.24) and yield (9.34) was recorded in Saharsa and for area (2.25) recorded in Purnea district.
During period IV (2010-11 to 2019-20), highest instability for production (60.83) and yield (46.47) was observed in Muzaffarpur and highest instability for area (32.65) was recorded in Dhanbad district. Whereas lowest instability in production (15.72) and yield (13.98) was observed in Saharsa and lowest instability in area (3.16) was recorded in Sitamarhi district.
During the overall period V (1980-81 to 2019-20), highest instability for area and production was observed in Sahibganj while highest instability in yield was recorded in Patna district. Lowest instability for area (7.93) was recorded in Saran whereas lowest instability for production (19.67) and yield (18.39) was observed in Saharsa district.
The instability for area varies from 2.76 to 99.62 percent, instability for production was varied between 13.24 to 119.98 percent and instability for yield of rice varies from 9.34 to 173.28 percent across the districts during the five periods. The range of instability for the state is very

narrow. For area, production and yield it varies from 5.11 to 9.55, 17.31 to 24.07 and 13.57 to 22.57 percent respectively.

3.3 Classification of Instability Index

The districts have been classified as very low instability, low instability, medium instability, high instability and very high instability based on the instability value of the area, production and yield of rice in Bihar (including Jharkhand). Number of districts fall under each class is presented in Figure 2. For area, most of the districts have classified as low instability and medium instability. Only few districts were observed with high instability and very high instability districts among all the periods.

None of the districts had shown very low instability for production and yield. Low instability for production was recorded in only two and one districts during period II and period III respectively while none for other three periods. Most of the districts were fall under medium instability class during period I (16) and period II (24), however maximum districts shows high instability during period III (18), period IV (25) and period V (21). None of the districts showed very high instability for production during period I, but during period III eleven and during period V eight districts were classified as very high instability districts.

For yield, the districts shows low instability decreases over the period. During period I, II, III, IV and V number of districts shows los instability were four, three, two, one and zero respectively. Most of the districts were classified for medium instability during period I (20) and II (46). Maximum districts observed high instability during period III (16), IV (21) and V (23). Few districts recorded very high instability and the values during period I, II, III, IV and V were zero, one, six, zero and three respectively for yield.

4. Conclusion

The study revealed that, for the state as a whole growth rate for area was negative for all the periods except period IV. The growth rate for production and yield was observed to be positive for all the five periods. Highest growth rate for production (6.21) and yield (4.51) was recorded during period IV. For the state as a whole, low instability was recorded during all the periods for area ranges from 5.11 to 9.55 percent. For production, medium instability was shown during all the periods ranged from 17.31 to 24.07 percent. For yield, period I classified as low instability (13.57), while medium instability was recorded during all other periods. The study will helpful for researchers, policy makers and other rice stakeholders for deciding their agricultural policy and effective implementation of agricultural policy in various districts of Bihar and Jharkhand state. Different policies can be modified and reoriented as per the requirement and need of the rice stakeholders of Bihar and Jharkahnd state.

Acknowledgements

The financial support received from the Indian Council of Agricultural Research, New Delhi, India, is thankfully acknowledged. The authors are thankful to the Director, ICAR- National Rice Research Institute, Cuttack, India for providing necessary facilities.

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Table 1: District wise growth rate of area, production and yield of rice in Bihar (including Jharkhand) f

S.N.	District	Area					Production						
		P-I	P-II	P-III	P-IV	P-V	P-I	P-II	P-III	P-IV	P-V	P-I	P-II
1	Patna	-1.01	-3.46	-3.97*	2.50*	-1.86*	2.16	5.88**	-10.78*	8.80*	0.06	3.20**	9.67
2	Nalanda	1.05	-0.23	-3.26*	4.03**	-0.67*	3.84	-0.73	-3.19	11.60*	0.74	2.76*	-0.5
3	Bhojpur	-0.12	-2.22*	-0.99	1.04*	-0.26*	2.56	6.33*	-1.04	4.99*	2.18*	2.69**	8.74
4	Rohtas	0.11	0.57	-1.33*	2.28*	0.11	0.53	5.16*	-2.06*	6.69*	3.01*	0.42	4.56
5	Gaya	-3.18**	0.27	-3.78**	2.97**	-1.28*	0.39	4.59	-3.74	7.17**	1.62*	3.69	4.31*
6	Nawada	0.66	0.46	-3.30	2.99*	-0.90*	3.85	4.10	-0.20	8.77*	1.87*	3.17	3.62
7	Aurangabad	1.14	1.38**	0.28	1.95*	0.55*	8.58*	6.48*	0.29	9.61*	3.64*	7.36*	5.03
8	Saran	0.64**	0.49	-1.13**	-1.74*	-0.75*	7.05*	3.12	-1.54	0.20	1.17*	6.37*	2.61
9	Siwan	2.94*	-0.45	0.79*	-1.73*	0.15	10.03*	1.67	-2.98**	3.30	1.44*	6.88*	2.13
10	Gopalganj	2.02*	-0.11	-1.55*	-3.47*	-0.43*	6.03*	2.04	-5.32*	-1.36	0.54	3.93*	2.15
11	Muzaffarpur	1.25*	-2.73*	1.57*	-3.18**	-0.52*	1.56	4.51	-8.95**	-1.32	0.76	0.31	7.44
12	East Champaran	-0.01	-0.47	1.23	0.55	-0.28*	2.22**	2.10	-7.34*	3.67	0.21	2.24*	2.58
13	West Champaran	-0.74*	0.56	-0.67	-0.86	-1.11*	1.57	4.55*	-7.71*	0.33	0.13	2.33**	3.97
14	Sitamarhi	-2.87**	-1.38	-3.31*	-1.00**	-0.59*	-1.05	3.48	-8.54**	6.23**	0.98**	1.87	4.93*
15	Vaishali	-1.37*	-0.38	-0.61	-1.60*	-0.87*	0.74	2.97	-5.90**	1.46	1.41*	2.14	3.36
16	Darbhanga	-0.47	-0.95	-0.05	-0.63	-1.04*	2.58	-1.66	-0.51	2.29**	0.67**	3.06	-0.72
17	Madhubani	0.08	-1.62	-0.13	1.55*	0.06	3.57**	1.37	-3.54	4.25*	0.97**	3.49**	3.04
18	Samastipur	0.39	-1.28	-0.68	-0.37	0.64*	-1.69	1.36	-6.56	6.85*	2.15*	-2.07	2.67
19	Begusarai	2.07**	-2.26	0.18	-7.16*	0.84*	1.77	0.60	-6.53**	6.49	2.58*	-0.30	2.92
20	Munger	0.64	-1.97	0.59	2.99*	-0.33**	8.02**	-0.71	4.41	11.64*	1.96*	7.33*	1.29
21	Bhagalpur	-0.07	0.74	-1.44*	0.32	-0.71*	3.41**	3.14	4.93*	2.18	2.01*	3.48**	2.38
22	Saharsa	1.16	3.40*	-1.87*	-0.22	1.07*	5.79*	7.73*	-2.46*	5.45*	3.51*	4.58*	4.18
23	Purnea	-0.78**	-1.25	-0.30	-1.18**	-0.62*	0.70	1.92	-3.58*	3.15	1.78*	1.49	3.22*
24	Katihar	1.52*	-0.62	-2.22*	-2.18**	-0.82*	3.97**	4.73	-4.67*	0.01	2.06*	2.42	5.38*
25	Ranchi		0.39	-4.02*	5.14*	-0.49		4.76**	-4.46**	14.33*	2.01*		4.35
26	Gumla		-0.23	-1.07	6.88*	0.12		-0.15	-2.16	18.54*	2.15*		0.08

27	Lohardaga		1.07	-2.48	7.52*	-0.96**		3.06	8.92	15.67*	2.02**		1.97
28	Singhbhum (East)		6.15*	-4.64	4.76*	-1.72*		12.08*	-6.75*	14.73*	0.94		5.59*
29	Singhbhum (West)		3.30	-2.72**	3.84*	0.24		8.37**	-4.40	12.86*	1.15		4.91*
30	Palamau	0.32	3.40**	-4.92*	8.06*	-0.39	2.81	5.39**	-3.35	15.92*	1.65*	2.48	1.93
31	Hazaribag	0.00	2.82	-7.21*	12.45*	-1.48*	1.63	9.40**	-9.74**	22.31*	0.26	1.62	6.40*
32	Giridih	1.39	0.71	-4.01**	5.48*	-0.99*	4.52	4.91	-4.98	16.76*	0.07	3.09	4.17
33	Dhanbad	0.29	0.61	-8.42*	7.98*	-2.26*	-1.18	3.32	-5.65**	13.05*	-0.59	-1.46	2.70
34	Dumka		0.40	-3.80	5.22	-0.99		4.40**	-4.51*	12.93*	-0.08		3.98*
35	Deogarh		-0.49	-5.91*	3.74*	-2.57*		0.26	-5.14	14.99*	-1.15		0.76
36	Godda		-0.76	-7.04*	3.31	-2.62*		3.33	-3.61	5.75	-1.31**		4.12*
37	Sahibganj		-0.10	-5.10	5.33*	-1.66**		5.04**	-8.99	14.14*	-1.25		5.14*
	State	-0.24	-0.27	-0.39	1.63*	-0.35*	2.30	1.13	0.41	6.21*	1.93*	2.55**	1.40

*significant at 1%, ** significant at 5%

P-I: Period I (1980-81 to 1989-90); P-II: Period II (1990-91 to 1999-2000); P-III: Period III (2000-01 to 2009-10); P
2019-20); P-V: Period V (1980-81 to 2019-20)

A: Area; P: Production; Y: Yield

Table 2: District wise instability rate of area, production and yield of rice in Bihar (including Jharkhand

S.N.	District	Area					Production						
		P-I	P-II	P-III	P-IV	P-V	P-I	P-II	P-III	P-IV	P-V	P-I	I
1	Patna	12.51	34.44	14.08	10.12	21.63	27.94	21.79	31.81	27.33	36.64	21.84	17
2	Nalanda	24.49	16.78	12.85	24.79	21.47	36.89	36.69	60.97	41.22	50.91	22.35	2
3	Bhojpur	7.06	18.04	7.31	3.33	10.18	19.46	17.58	38.44	18.51	26.08	14.70	3
4	Rohtas	9.16	6.10	7.36	4.44	8.18	26.70	17.98	14.50	18.63	22.49	23.14	1
5	Gaya	18.38	14.23	25.80	22.38	20.38	40.79	30.25	52.39	43.46	42.38	25.97	2
6	Nawada	20.38	28.47	24.04	12.83	23.38	38.39	51.03	52.70	37.59	45.25	26.00	3
7	Aurangabad	14.21	10.06	17.91	10.34	12.60	17.78	18.56	42.02	23.27	33.09	18.62	1
8	Saran	2.84	8.01	5.38	6.15	7.93	16.61	29.28	25.56	30.95	28.97	16.40	2
9	Siwan	4.27	7.21	2.52	6.55	9.54	15.76	22.56	31.95	33.50	31.83	14.45	1
10	Gopalganj	3.49	5.61	5.79	16.40	11.76	16.57	21.16	20.90	42.09	32.26	15.42	1
11	Muzaffarpur	6.84	9.01	8.68	31.75	17.73	27.99	29.47	56.00	60.83	50.50	23.75	2
12	East Champaran	2.76	10.56	5.93	9.61	8.70	15.18	22.86	41.09	38.39	32.60	12.93	1
13	West Champaran	3.83	10.85	8.89	8.99	8.56	16.32	15.19	40.13	26.30	29.01	14.02	1
14	Sitamarhi	14.38	19.27	18.92	3.16	15.44	34.82	34.73	44.42	39.33	42.77	27.22	3
15	Vaishali	3.59	5.75	3.20	7.40	10.05	26.66	27.43	40.92	41.69	36.45	26.89	2
16	Darbhanga	19.19	23.01	11.57	7.90	17.45	42.14	16.20	35.33	18.43	29.43	30.48	2
17	Madhubani	11.44	21.13	6.25	5.69	13.45	31.11	37.49	46.59	33.33	38.80	28.91	3
18	Samastipur	8.62	14.02	12.57	7.01	10.37	38.84	32.93	71.51	30.54	48.60	36.08	3
19	Begusarai	18.06	27.00	11.29	9.79	25.53	46.03	53.62	50.27	44.51	52.90	30.48	4
20	Munger	10.41	19.24	10.76	12.88	14.71	26.41	31.63	40.25	38.59	40.48	21.38	2
21	Bhagalpur	10.60	7.22	4.25	4.45	8.29	19.47	17.91	21.87	30.68	27.97	18.34	1
22	Saharsa	9.28	10.39	5.12	3.67	12.21	21.70	15.38	13.24	15.72	19.67	17.04	2
23	Purnea	7.29	9.23	2.25	11.83	8.72	23.25	21.89	22.20	24.42	27.48	18.51	1
24	Katihar	5.99	15.17	3.93	16.64	11.84	27.67	35.75	22.20	29.23	32.75	26.90	2
25	Ranchi	-	9.46	16.92	16.79	17.72	-	19.37	32.54	38.35	45.81	-	1
26	Gumla	-	11.15	15.72	16.25	19.72	-	23.43	35.54	35.14	58.67	-	1

27	Lohardaga	-	14.82	32.67	18.87	27.51	-	29.78	109.90	37.60	72.33	-	3
28	Singhbhum (East)	-	18.22	55.43	27.49	41.70	-	27.60	54.56	38.08	49.95	-	2
29	Singhbhum (West)	-	24.29	12.69	15.95	19.48	-	40.52	34.35	34.54	45.09	-	2
30	Palamau	9.70	15.14	27.13	24.42	24.75	32.60	27.51	75.26	47.33	61.84	27.27	2
31	Hazaribag	3.29	13.01	16.52	26.50	25.49	33.67	25.75	50.59	30.26	54.34	32.04	2
32	Giridih	9.22	22.17	17.75	23.49	20.95	32.69	35.45	44.75	40.70	49.38	28.68	2
33	Dhanbad	9.77	17.47	30.49	32.65	27.64	30.56	22.35	47.36	59.52	46.44	24.82	1
34	Dumka	-	5.82	9.47	11.31	17.63	-	13.38	22.30	37.63	44.16	-	1
35	Deogarh	-	14.25	9.17	17.51	19.44	-	19.97	44.07	49.30	46.37	-	1
36	Godda	-	16.99	26.02	22.20	23.68	-	34.66	35.54	56.51	42.28	-	2
37	Sahibganj	-	12.70	99.62	10.10	71.96	-	21.27	119.98	39.71	76.21	-	2
	State	6.09	5.11	7.16	9.55	6.97	17.31	23.91	24.07	22.22	23.43	13.57	2

P-I: Period I (1980-81 to 1989-90); P-II: Period II (1990-91 to 1999-2000); P-III: Period III (2000-01 to 2009-10); P-IV: Perio
P-V: Period V (1980-81 to 2019-20)
A: Area; P: Production; Y: Yield

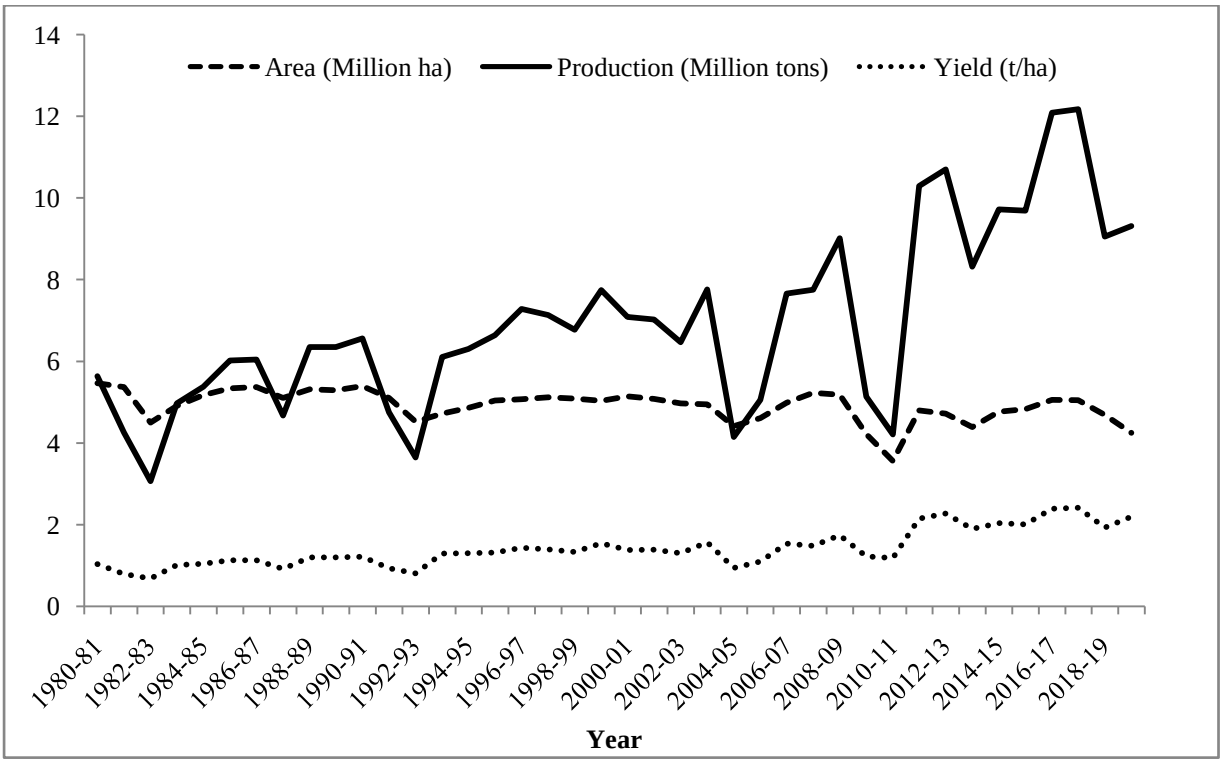

Figure 1: Area, production and productivity of rice in Bihar (including Jharkhand) from 1980-81 to 2019-20

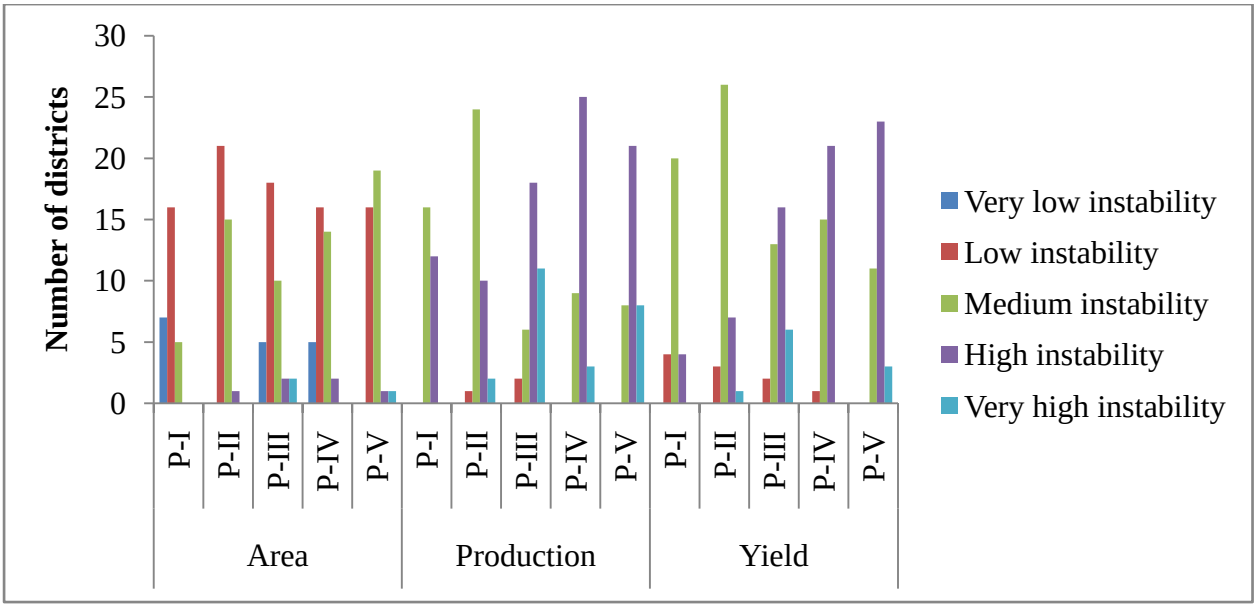

Figure 2: Number of districts under each instability class for area, production and yield of rice during five periods in Bihar (including Jharkhand)

P-I: Period I (1980-81 to 1989-90); P-II: Period II (1990-91 to 1999-2000); P-III: Period III (2000-01 to 2009-10); P-IV: Period IV (2010-11 to 2019-20); P-V: Period V (1980-81 to 2019-20)