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Analysis of Growth and Instability of Rice Production in Madhya Pradesh, India: A District Level Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Rice is one of the important food crops cultivated in Madhya Pradesh state covering 4.55% rice area and 3.72% rice production of the country. Its contribution is very vital in agricultural growth of the country. But, yield of the state is less than the national average yield. So, for further improvement of its contribution in the agriculture sector of the country, it is essential to study the growth pattern of rice production in the state. Therefore the present study has been undertaken to examine the growth rate and instability in area, production and yield of rice in Madhya Pradesh

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state. The district-wise data on rice of Madhya Pradesh state was collected from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India and from the online sources of the state departments for the period 1992-93 to 2019-20. The data was divided into four periods for analysis. Compound annual growth rate and Cuddy-Della Valle Instability index have been computed for the four periods. The districts have been classified into five classes based on the classification of instability. These classes are very low instability, low instability, medium instability, high instability and very high instability. For the state, growth rate for area ranges from -0.80 to 4.23; for production ranges from 0.90 to 12.82 and for yield ranges from 1.31 to 8.24. The highest growth rate for area and production was observed in Hosangabad and Raisen districts respectively in period III; and for yield Datia district in period I. For the state instability ranges from 3.77 to 9.00 for area, 5.93 to 30.70 for production and 6.29 to 22.57 for yield. None of the districts were classified as very low instability for production and yield. Most of the districts recorded medium instability in period I, II and III for yield. The information about growth rate and instability may help the policy makers of Madhya Pradesh state to select the appropriate districts for enhancing the rice yield of the state.

Keywords: Rice; production; growth rate; instability; Madhya Pradesh.

1. INTRODUCTION

Rice is the staple food for about half of the world's 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 was grown in more than 46.27 million hectare area with the production of 129.47 million tons of milled rice in 2021-22 contributing approximately 25% of the global rice production. Rice cultivation engages 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 35.6% of the food grain area of the country.

Madhya Pradesh is the tenth largest rice producing state of the country producing 4.81 million tons of rice in 2.11 million hectares of area with an average yield of 2.80 tons per hectare contributing 3.72% of rice production and 4.56% rice area of the country.

“For higher growth of agriculture, a quantitative assessment of the contribution of different factors to agricultural output growth is important for reorienting the programmes and prioritizing agricultural development. Various factors affect the growth of agricultural output. Major of these factors is area and yield” [1,2]. “These major sources of output growth have significance in finalizing programmes of agricultural development and priorities of investment in it [3,4]. Hence, it may be vital to find the reasons for growth rates different from one another, to remove the bottlenecks to achieve the fast development of the agricultural sector” [5]. 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 thereby hampering the economic growth of the state.

Samal et al [6] studied the state-wise analysis of production of rice in India. “District wise growth rate and instability of rice have been analyzed by the researchers for some states” [7-12]. Some researchers studied growth and instability in Madhya Pradesh. Kumar et al [13] studied the growth and instability of paddy and wheat crop in Gwalior district of Madhya Pradesh; Mishra et al [14] analyzed the growth and instability of major *kharif* crops in Madhya Pradesh; Balai et al [15] studied the growth, decomposition and instability of major *rabi* pulse crops in Madhya Pradesh, but the district-wise study on rice in Madhya Pradesh state over the long period is not available.

Therefore, the present study is undertaken to analyze the district wise growth rate and instability of area, production and yield of rice in Madhya Pradesh state.

2. MATERIALS AND METHODS

The present study is done based on the secondary rice data of Madhya Pradesh state collected during the years 1992-93 to 2019-20. The district-wise data on the area, production and yield of rice of Madhya Pradesh state was collected from the Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of

Agriculture and Farmers Welfare, Government of India during the last ten years. Last twenty eight years rice data from 1992-93 to 2019-20 have been used in the present study. There are fifty five districts in Madhya Pradesh. Some districts were carved out to become new districts during last few years. The analysis have been done from 1992-93 data, therefore the bifurcated districts were merged for the analysis with sum of twenty five districts. For lucidity, the twenty eight years rice data have been divided into four periods; period I (1992-93 to 1999-2000), period II (2000-01 to 2009-10), period III (2010-11 to 2019-20) and lastly the overall period as a period IV (1992-93 to 2019-20).

The district-wise growth rate of area, production and yield of Madhya Pradesh state for each period is computed to study the growth pattern in area, production and yield of that district.

The compound growth rate was estimated using the following exponential [16].

$$Y = ab^t$$

Log Y = log a + t log b

CGR(r) =[Antilog(log b) -1] × 100

where,

CGR = Compound growth rate
t = time in the year
Y= area/production/productivity
a and b = Regression parameters

The performance of agricultural output is affected by climatic factors so the growth rate has been calculated based on three years of average data [16-18].

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 the Cuddy-Della Valle index [19]. This method is used to examine the extent of risk involved in crop production.

The instability in area, production and yield has been computed 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 degrees of freedom

Classification methodology for instability proposed by Jambhulkar et al, [10,11] has been used to classify the instability into five classes as follows:

List 1. Classification methodology for instability

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 area (million hectares), production (million tons) and yield (t/ha) of rice in Madhya Pradesh state from 1992-93 to 2019-20 is depicted in Fig. 1. The rice area is increased by 1.36 times, rice production is increased by 4.41 times and rice yield is increased by 3.22 times during the last twenty eight years. The rice area is almost similar, but the rice production and rice yield increased significantly.

3.1 Compound Annual Growth Rate

The district-wise growth rate of area, production and yield of rice in Madhya Pradesh has been presented in Table 1. It revealed that the growth rate ranges from -19.31 to 39.40 across the districts for area, production and yield during the studied four periods.

During the period I (1992-93 to 1999-2000), the highest growth rate for area (12.74) was observed in Gwalior district and for production (20.53) and yield (18.47) was recorded in Datia district. The lowest growth rate for area (-4.62) and production (-5.74) was observed in Sehore district and lowest yield (-1.69) was recorded in recorded in Tikamgarh district. The growth rate for the state was positive for all area, production and yield.

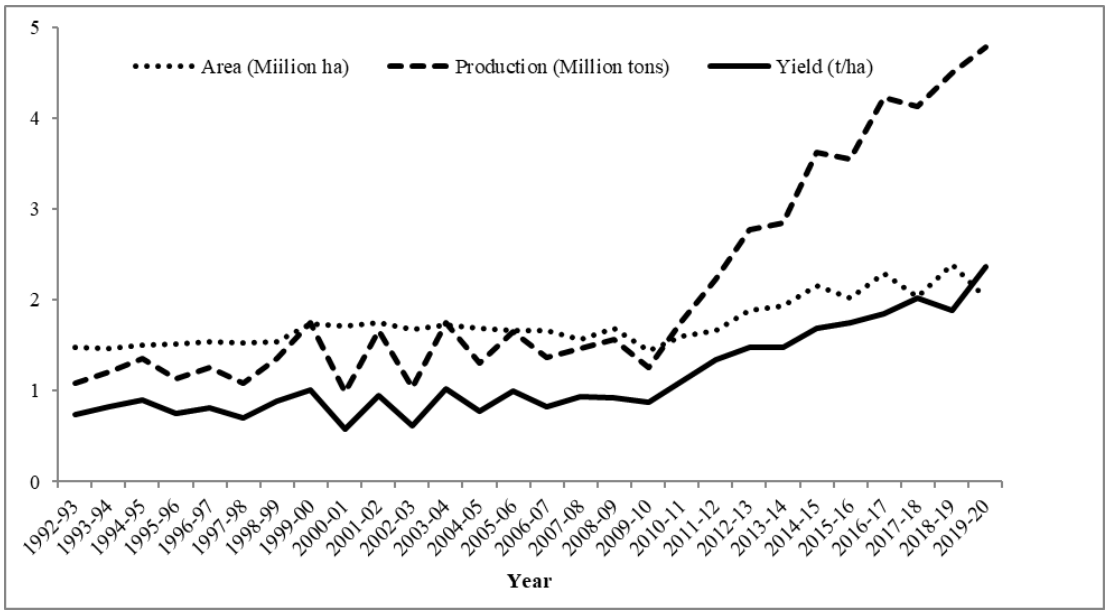

Fig. 1. Area (million hectares), production (million tons) and yield (t/ha) of rice in Madhya Pradesh during 1992-93 to 2019-20

During period II (2000-01 to 2009-10), highest growth rate for area (19.57) and production (24.11) was recorded in Raisen district while highest growth rate for yield (5.37) was observed in Chhindwara district. The lowest growth rate for all area (-19.31) and production (-19.04) was found in Bhind district and for yield was found in Tikamgarh district. In this period, the growth rate for the state was observed to be negative for area, and positive for production and yield.

During period III (2010-11 to 2019-20), the highest growth rate for area (28.22), production (39.40) and yield (16.86) was observed in Hosangabad, Raisen and Rewa districts respectively. The lowest growth rate for the area (-15.62) and production (-15.43) was recorded in Tikamgarh district while lowest growth rate for yield (-1.02) was observed in Chhindwara district. In this period, the growth rate for production and yield was observed to be positive for all the districts except two districts; and for the state it was positive for all area, production and yield.

During overall period IV (1992-93 to 2019-20), the highest growth rate for the area (18.64) and production (22.45) was recorded in Datia and highest growth rate for yield (6.34) was observed in Sehore district. The lowest growth rate for area (-5.94), production (-8.40) and yield (-2.62) was observed in Tikamgarh district. The growth rate yield was observed to be positive for all the districts except two districts; and for the state it was positive for all area, production and yield.

In most of the cases, the highest and lowest growth rate was observed in same districts. A similar trend was observed in Punjab [8] and Telangana [9]. The lowest growth rate was observed in Tikamgarh, Bhind, Sehore and highest growth rate was observed in Datia, Raisen districts.

3.2 Cuddy-Della Valle Instability Index

The level of instability cannot be detected by focusing only on growth rates. The growth rate will only 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 area, production and yield of rice was determined by using Cuddy-Della Valle Instability Index.

The Cuddy-Della Valle Index for area, production and yield of rice in Madhya Pradesh has been presented in Table 2. During period I (1992-93 to 1999-2000), the highest instability for the area (47.78), production (56.43) and yield (37.22) was found in Datia, Morena and Jhabua districts respectively whereas the lowest instability for the area (0.31) was observed in Damoh district, and for production (12.17) and yield (11.36) was observed Balaghat district.

Table 1. District-wise growth rate of area, production and yield of rice in Madhya Pradesh for various periods

District	Area				Production				Yield			
	P-I	P-II	P-III	P-IV	P-I	P-II	P-III	P-IV	P-I	P-II	P-III	P-IV
Jabalpur	1.93	-0.41	6.49	1.35	2.04	-1.02	19.12	6.16	0.11	-0.62	11.87	4.75
Balaghat	0.16	0.04	1.07	0.40	0.58	1.79	6.77	2.86	0.42	1.74	5.64	2.45
Chhindwara	1.40	-2.74	5.74	0.40	0.88	2.47	4.66	4.64	-0.52	5.37	-1.02	4.23
Seoni	-	0.72	3.95	2.08	-	4.77	9.49	7.86	-	4.02	5.33	5.66
Mandla	1.50	0.95	2.80	1.36	3.66	1.96	18.03	5.27	2.13	1.01	14.82	3.86
Narsinghpur	-4.28	3.14	20.92	5.45	-3.38	2.99	34.48	9.27	0.95	-0.14	11.21	3.62
Sagar	-3.68	-3.75	0.45	-2.53	-2.38	-4.32	6.24	-1.17	1.35	-0.59	5.76	1.40
Damoh	-0.12	0.21	5.31	1.11	-0.84	1.55	12.64	4.23	-0.72	1.34	6.96	3.08
Panna	0.65	-1.65	1.77	0.25	1.22	-0.37	13.29	4.62	0.57	1.30	11.33	4.36
Tikamgarh	-2.94	-6.72	-15.62	-5.94	-4.57	-14.49	-15.43	-8.40	-1.69	-8.34	0.22	-2.62
Chhatarpur	0.04	-6.03	-6.95	-5.47	-0.72	-10.63	-5.49	-6.11	-0.76	-4.89	1.57	-0.68
Rewa	1.01	-0.22	4.60	0.52	3.57	-0.21	22.24	5.79	2.54	0.01	16.86	5.25
Sidhi	2.06	0.56	2.39	0.78	3.25	2.00	16.67	6.83	1.17	1.43	13.95	6.00
Satna	0.25	-2.14	8.11	-0.46	2.91	-2.98	21.53	5.26	2.66	-0.86	12.41	5.74
Sahadol	1.25	0.17	1.92	0.51	1.20	0.96	10.10	4.43	-0.05	0.79	8.02	3.91
Jhabua	-0.99	-0.95	-5.90	-2.69	2.62	2.85	2.13	-0.09	3.64	3.84	8.53	2.68
Morena	6.14	-2.59	16.00	8.85	10.43	1.30	17.52	11.71	4.04	4.00	1.30	2.63
Bhind	5.12	-19.31	10.37	-3.00	4.37	-19.04	14.70	-0.33	-0.72	0.34	3.93	2.75
Gwalior	12.74	-8.50	7.32	3.79	12.46	-7.03	6.87	4.87	-0.25	1.61	-0.42	1.04
Shivpuri	1.62	1.20	10.89	5.67	4.36	1.31	18.33	8.90	2.70	0.11	6.71	3.06
Datia	1.74	6.59	25.00	18.64	20.53	5.70	28.92	22.45	18.47	-0.84	3.14	3.21
Sehore	-4.62	6.33	21.18	12.47	-5.74	7.53	34.55	19.60	-1.17	1.13	11.03	6.34
Raisen	-2.60	19.57	27.12	16.26	-1.53	24.11	39.40	21.22	1.10	3.80	9.66	4.26
Betul	-0.89	1.55	-1.27	1.62	3.49	3.82	1.27	5.16	4.41	2.23	2.58	3.49
Hosangabad	-1.08	6.71	28.22	10.42	0.24	9.19	28.81	14.45	1.33	2.32	0.46	3.65
State	1.10	-0.80	4.23	1.31	2.42	0.90	12.82	5.03	1.31	1.71	8.24	3.67

P-I: Period I (1992-93 to 1999-2000); P-II: Period II (2000-01 to 2009-10); P-III: Period III (2010-11 to 2019-20); P-IV: Period IV (1992-93 to 2019-20)

Table 2. District-wiseinstability of area, production and yield of rice in Madhya Pradesh for various periods

District	Area				Production				Yield			
	P-I	P-II	P-III	P-IV	P-I	P-II	P-III	P-IV	P-I	P-II	P-III	P-IV
Jabalpur	1.39	7.40	17.07	20.07	21.99	33.97	35.18	66.68	21.98	28.72	27.29	41.19
Balaghat	1.64	3.33	11.45	8.04	12.17	21.13	20.62	25.06	11.36	19.87	13.37	17.87
Chhindwara	8.77	3.09	43.51	26.20	24.24	21.34	38.88	46.72	18.98	18.68	23.57	44.08
Seoni	-	2.35	12.16	10.46	-	30.61	36.17	37.31	-	28.78	30.93	30.69
Mandla	0.71	3.30	8.82	8.09	16.46	21.51	25.80	49.04	15.97	19.66	32.77	43.71
Narsinghpur	10.53	5.99	24.55	56.93	18.76	18.36	49.34	101.72	11.71	15.22	43.80	44.49
Sagar	4.99	7.33	15.42	13.39	15.34	17.70	40.20	35.06	13.36	13.16	34.87	33.80
Damoh	0.31	2.38	6.57	10.96	14.09	23.84	29.05	41.89	13.99	23.50	21.77	29.47
Panna	3.23	5.43	14.55	10.89	18.44	26.56	46.45	59.27	17.60	24.78	47.34	54.74
Tikamgarh	3.40	9.53	24.71	16.33	24.78	40.87	50.41	35.41	22.89	35.32	50.24	36.93
Chhatarpur	1.75	6.81	36.33	13.59	23.79	35.19	58.80	36.05	23.49	30.01	37.92	33.84
Rewa	3.21	4.14	24.64	21.56	25.32	29.04	36.18	69.16	25.57	25.88	51.56	63.75
Sidhi	2.91	3.06	14.52	12.36	23.94	26.15	30.59	52.72	22.28	24.89	27.11	41.14
Satna	7.13	4.91	12.74	22.86	29.44	46.57	17.07	57.91	25.50	41.70	20.59	40.41
Sahadol	1.00	2.56	10.94	8.49	17.03	23.40	21.82	35.50	16.50	22.37	17.12	29.40
Jhabua	2.80	3.32	9.20	7.49	40.98	34.81	37.76	42.40	37.22	33.62	27.60	38.45
Morena	40.49	43.85	44.16	83.29	56.43	47.04	53.14	101.05	14.87	30.70	17.85	23.19
Bhind	8.25	91.47	66.94	72.77	19.47	95.70	83.15	101.45	21.19	23.29	29.49	28.69
Gwalior	10.44	47.71	42.89	50.38	23.91	60.98	50.60	61.46	14.76	25.96	21.08	20.49
Shivpuri	7.27	17.39	63.13	80.34	17.66	39.91	76.85	126.32	14.28	29.45	26.44	32.07
Datia	47.78	43.26	55.56	122.83	55.79	59.33	45.13	123.30	17.10	26.62	26.90	29.91
Sehore	7.13	46.12	22.32	69.29	26.41	59.28	40.83	102.48	24.58	13.52	30.89	50.55
Raisen	15.68	28.05	23.10	84.57	22.04	43.87	35.59	113.00	14.19	15.02	23.54	36.25
Betul	9.99	2.79	19.72	17.74	16.12	12.35	32.67	39.16	12.20	11.81	22.69	29.67
Hosangabad	5.80	5.76	18.31	73.48	15.12	15.41	24.16	86.45	13.52	11.22	54.70	50.92
State	3.77	3.78	8.23	9.00	14.43	19.44	5.93	30.70	11.28	17.07	6.29	22.57

P-I: Period I (1992-93 to 1999-2000); P-II: Period II (2000-01 to 2009-10); P-III: Period III (2010-11 to 2019-20); P-IV: Period IV (1992-93 to 2019-20)

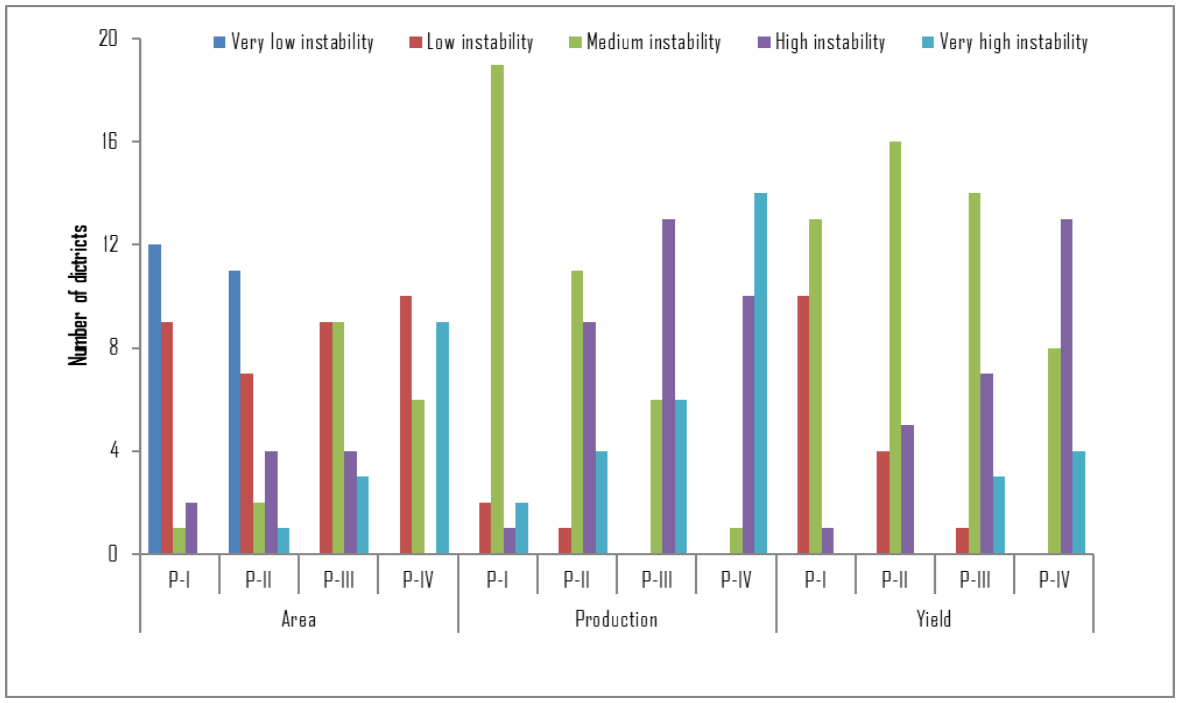

Fig. 2. Number of districts under each instability class for area, production and yield of rice during four periods in Madhya Pradesh state

P-I: Period I (1992-93 to 1999-2000); P-II: Period II (2000-01 to 2009-10); P-III: Period III (2010-11 to 2019-20); P-IV: Period IV (1992-93 to 2019-20)

During period II (2000-01 to 2009-10), the highest instability for the area (91.47) and production (95.70) was observed in Bhind district and for yield (41.70) observed in Satna district while the lowest instability for area (2.35), production (12.35) and yield (11.22) was observed in Seoni, Betul and Hosangabad districts respectively.

During period III (2010-11 to 2019-20), the highest instability for the area (66.94) and production (83.15) was observed in Bhind district and for yield (54.70) recorded in Hosangabad district whereas the lowest instability for area (6.57), production (17.07) and yield (13.37) was recorded in Damoh, Satna and Balaghat districts respectively.

During the overall period IV(2092-93 to 2019-20), the highest instability for the area (122.83), production (126.32) and yield (63.75) was observed in Datia, Shivpuri and Rewa districts respectively. The lowest instability for area (7.49) was recorded in Jhabua district whereas for production (25.06) and yield (17.87) it was recorded in Balaghat district.

The instability varies from 0.31 to 122.83 per cent for the area, 12.17 to 126.32 per cent for production and 11.22 to 63.75 per cent for yield across districts during the four periods. The instability for the state for area, production and yield vary from 3.77 to 9.00, 5.93 to 30.70 and 6.29 to 22.57per cent respectively.

The instability for area of the state as a whole is classified as very low and low instability; and for the production is classified as low instability and medium instability. Similar trend was observed in Jambhulkar et al [11].

3.3 Classification of Instability Index

All districts of Madhya Pradesh 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. The number of districts that fall under each class has been presented in Fig. 2.

For area, most of the districts fall under the class very low instability and low instability during period I and period II. None of the districts fall under the class very low instability during period

III and period IV, very high instability during period I and high instability during period IV. In period III, most of the districts fall under the class low instability and medium instability and during period IV most of the districts fall under the class low instability and very high instability.

For production, none of the districts showed very low instability in all the periods. This is in line with Jambhulkar et al [11]. None of the districts recorded low instability in period III and IV. Most of the districts fall under medium instability in period I and II, high instability in period III and very high instability in period IV. Very few districts recorded low instability in period I and II and medium instability in period IV.

For yield, none of the districts were classified as very low instability in all the periods. Similar result was observed in Jambhulkar et al [11]. None of the districts were classified as very high instability in period I and II; and low instability in period IV. Most of the districts were classified as medium instability in period I, II and III and high instability in period IV. Only one district recorded low instability in period III and high instability in period I.

4. CONCLUSION

The study revealed that, for the state as a whole growth rate for production and yield was positive in all the periods. The growth rate varies from -0.80 to 4.23 for area, 0.90 to 12.82 for production and 1.31 to 8.24 per cent for yield. For the state as a whole, for the area, production and yield highest growth rate was recorded during period III for production whereas the lowest growth rate was recorded for area during period II. For the state as a whole, the instability for area ranges from 3.77 to 9.00, for production ranged from 5.93 to 30.70 and for yield ranges from 6.29 to 22.57. Lowest instability was observed for area in period I however lowest instability was observed for production in period IV. None of the districts recorded very low instability for production and yield. Most of the districts recorded medium instability for yield in period I, II and III for production in period I and II. The information described in previous sections may help the planners or policy makers of Madhya Pradesh state to select the districts for enhancing the rice yield by providing additional support from government to the selected districts.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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