

Research Paper

Area, Production and Yield of Paddy, Wheat and Gram in India vis-à-vis Chhattisgarh: A Spatio-temporal Analysis

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ABSTRACT

This paper studied the growth behaviour, instability and effects of area, yield and their interaction to the production of paddy, wheat and gram, the major staple commodities. The study based entirely on secondary data from the period 2000-01 to 2019-20. The results indicated that area and production of paddy and wheat steadily increased over years, while for gram, the quantum of increase was greater. Analysis of gram production growth indicated highest area effect mostly responsible in increasing production of gram in India. Similar situation of growth rates has been depicted for state-wise production of gram followed by wheat and paddy in India, however, study reveals low growth-low risk association depicting less desirable situation for major producing states of paddy and wheat while, gram reveals low growth-medium risk association. Chhattisgarh has increased its share in APY of paddy, wheat and gram to the India. Selected districts of Chhattisgarh plains mostly revealed low growth-medium risk association, which is less desirable for production of paddy, wheat and gram in those districts. The area effect was more strongly responsible for wheat whereas, yield effect for paddy in the production of these crops in those selected districts of Chhattisgarh plains.

HIGHLIGHTS

- Chhattisgarh state remarked drastically decline in area and production of wheat (>75%), whereas gram increased in both (>80%), while paddy increased (>50%) its production only, followed increasing trend in yield of these crops during study periods.
- India and Chhattisgarh state, evident of non-significant and marginally low annual compound growth rate of 0.07 and 0.14 percent, respectively in area of paddy during 2000-01 to 2019-20.

Keywords: CAGR, Chhattisgarh, CV, Decomposition, Gram, Instability, LGR, Paddy, Wheat

Growth in the agriculture sector is two to four times more effective in raising incomes among the poorest compared to other sectors (TWB, 2022). It has become the matter of concern to researchers and policy makers, as increasing total agricultural production with high rates of growth is one of the main objective of development plans. Indian agricultural development has great critic that it having regionally concentrated growth for a few agricultural commodities. The disaggregated

analysis of agricultural productivity would decipher these issues and will help in identifying and prioritizing the districts for agricultural development (Patil and Yeledhalli, 2016). Percentages are of GVA of agriculture and allied sector to total economy was increased by 0.80 to 1.80 during 2019-20 (18.4%) and

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2020-21 (20.2%), respectively, hence agriculture is very crucial to economic growth. Agriculture has been the bright spot in the Indian economy despite COVID-19 situation. At latest, out of gross cropped area (60%) of country, rice, wheat and gram reported 25.25, 16.04 and 4.04 percent, respectively (DESCG, 2021). Chhattisgarh is a state of central India known for rice cultivation called '*rice bowl of India*' divided into 3 agro-climatic zones i.e., Bastar plateau, Chhattisgarh plains and Northern hills based on climate and topography. The prime geographical landmarks that have been marked as the productive areas in which paddy, wheat, maize, arhar, gram, jowar and groundnut are major crops grown in Chhattisgarh. In 2019-20, the State has reported 41.60 percent of gross cropped area (5,735 thousand ha) within which share of paddy, wheat gram was 74.39, 2.03 and 7.32 percent, respectively, with 80.82 percent net sown area (4,635 thousand ha). Chhattisgarh agriculture, with each passing day is gaining a new momentum, which will help it to forward its steps towards an economically viable phase. Estimates on growth in area, production and yield help us to understand how production is changing over time, what are the driving forces behind the changes in production, yield or area under the crop. On the other hand, estimates on variability help us to know the nature and extent of instability and risk in the production process (Deb and Pramanik, 2015). The continuous appraisal of growth in yield along with analysis of instability has a supreme importance for future policy and planning. In this context, the present study intended to capture the whole picture of growth performance in India and its special concern to the selected districts of Chhattisgarh plains with instability and contribution of area, yield and its interaction to the production of major growing crops.

DATA AND METHODOLOGY

Present study is entirely based on the 20 years secondary time-series data regarding APY of selected paddy, wheat and gram crops for India and Chhattisgarh, during period 2000-01 to 2019-20 from Directorate of Economics & Statistics, DAC&FW, Govt. of India, Directorate of Economics and Statistics, Govt. of Chhattisgarh, and various Govt. issues. The collected data were analyzed for growth, instability and decomposition of production

in selected major crops of study. The analysis of study further extended to the selected districts i.e., Raipur, Mahasamund, Dhamtari and Durg districts of Chhattisgarh plains to analyze growth and instability dynamics. Following statistical tools and techniques were used to analyze the study objective.

(a) Growth rate dynamics

(i) Linear Growth Rates: This helps to estimate the constant absolute increase in per unit time.

$$Y = a + \hat{b} X$$

Where, Y = Area/Production/Yield of the selected crops. X = time variable indicating number of years, base year allotted the value 1 and subsequent years as 2, 3, ..., n . a = Intercept, \hat{b} = Regression coefficient or trend value.

$$r = \frac{\hat{b}}{\bar{Y}} \times 100$$

Where, r = Percent Linear growth rate, and \bar{Y} = Mean of Y .

(ii) Compound annual growth rates: Regressing time variable on $A/P/Y$, the procedure to estimate compound growth rates.

$$Y = a.b^t$$

Where, Y = Area/Production/Yield of crops, t = Time (independent variable), b = Regression coefficient and a = Intercept. The above equation can be written as, $\log Y = \log a + t \log b$. The average annual compound growth rates ' r ' will be computed by using the following formula:

$$CAGR (r) = [Antilog (\log b) - 1] \times 100.$$

(b) Instability analysis

$CDVI (\%) = CV \times \sqrt{1 - \bar{R}^2}$... (Cuddy and Della Valle, 1978). Where, $CV (\%)$ = Coefficient of variation = Standard deviation/Mean, \bar{R}^2 is the coefficient of determination from time trend regression adjusted by the number of degrees of freedom (Vasavada and Shiyani, 2021).

For assessment of risk factor in production of selected crops for the selected states/districts was done by analyzing growth-instability trade off

represented by classifying them accordingly (e.g., Reddy and Mishra, 2010; Sihmar, 2014; Das *et al.*, 2016; Vasavada and Shiyani, 2021). Instability analysis ranges between (0 to >30): Low instability (0 to 15); Medium instability (15 to 30) and High instability (>30). Growth rate ranges between (0 to >10): Low growth rate (0 to 5); Medium growth rate (>5 to 10) and High growth rate (>10).

(c) Decomposition analysis: To measure the effect of area, yield and their interaction towards increasing production of the crop concern, the method state that if A_0 , P_0 and Y_0 respectively area, production and productivity in base year and A_n , P_n and Y_n are values of the respective variable in n^{th} year item. (Jagannath *et al.* 2013).

$$\text{Production} = \frac{A_0 \Delta Y}{\Delta P} \times 100 + \frac{Y_0 \Delta A}{\Delta P} \times 100 + \frac{\Delta Y \Delta A}{\Delta P} \times 100$$

[Production = Productivity effect + Area effect + Interaction effect]. Thus, the total change in production can be decomposed into three components viz., yield effect, area effect and the interaction effect due to change in yield and area.

RESULTS AND DISCUSSION

India's growth performance during 2000-01 to 2019-20: The study was found very little significant fluctuations in area and yield of paddy, wheat, gram, total cereals, total pulses and foodgrains in India during 2000-01 to 2019-20. Similarly, the production of paddy and wheat found slow but steady increasing trend in which paddy has increased from 84.98 million tonnes to 118.87 million tonnes (39.88%) and wheat from 69.68 million tonnes to 107.86 million tonnes (54.79%) from 2000-01 to 2019-20, respectively. While, gram production has found large fluctuations with its increasing trend. Its production was increased by more than three times i.e., 3.5 million tonnes (2000-01) to 11 million tonnes (2019-20) during study period which was evident to have one of the major contributors in total pulses. It was evident from figure that India's total foodgrain production were found increasing over the study period (2001-02 to 2020-21) in which cereals have significant share more than the pulses showing similar growth trend along with foodgrains. Similarly, figure depicting similar trend with gram in total pulses production (See Appendix I).

The average area under paddy and wheat was found increased by 4.70 and 15.55 percent during TE 2004-05 to TE 2019-20, respectively however, only gram has increased its average area more than 50 percent in study period. Similarly, average production of paddy, wheat and gram was found highly increased during TE 2004-05 to TE 2019-20 by 42.97, 50.72 and 109.98 percent, respectively again gram remarked significant increase of more than doubled production. The yield of paddy, wheat and gram of India found increased by 36.74, 30.47 and 39.18 percent during TE 2004-05 to TE 2019-20 (See Appendix III-India).

The absolute percentage share of paddy and wheat in total foodgrain on triennium ending basis was more or less increase showed little variation in area as well as in production except gram which, area and production share was increased by more than 40 percent. Total foodgrains showed only 5.89 percent and 47.99 percent increase in area and production, respectively during TE 2004-05 to TE 2019-20 (See Appendix II).

Growth and instability in India: From the Table 1 below, it was observed that the average area and production of paddy was higher than wheat followed by gram whereas, average yield of wheat found highest (2951.25 kg/ha) than paddy and gram. Study evident of prevailing low instability (i.e., 0 to 15%) in APY (i.e., area, production and yield) of paddy, wheat, gram and total foodgrains as well as very low annual compound growth rates (<5%) in India during study period. While, production has found slightly higher and positively significant growth rates (at 1 percent level of significance) compare to area and yield of respective crops. It was also evident that APY of paddy, wheat, gram and total foodgrains in India during study period found positive and highly significant at 1 percent level of significance except area of paddy found non-significant result showing very least growth rate 0.07 percent. However, only gram has observed highly positive and significant growth rate in production (4.77%) and area (2.92%) which was highest among paddy and wheat. The instability was found higher for gram in production (11.75%) than area and yield the result was similar in line with Reddy and Mishra (2010) for all the periods. Study reveals low growth-low risk character which is less desirable, for APY of selected crops in India.

Table 1: Growth rates dynamics and instability in APY of paddy, wheat, gram and total foodgrains in India during 2000-01 to 2019-20

Particulars	Paddy	Wheat	Gram	Foodgrains
	Area			
Mean (million ha)	43.55	28.57	8.07	123.36
CDVI	2.49	2.81	7.33	2.09
LGR	0.07	1.06	2.77	0.29
CGR	0.07 ^{NS}	1.07 ^{***}	2.92 ^{***}	0.29 ^{***}
Adj R ²	-0.03	0.83	0.83	0.38
Production				
Mean (million tonnes)	98.64	84.70	7.37	238.88
CDVI	5.75	4.85	11.75	5.16
LGR	1.86	2.47	4.50	2.25
CGR	1.90 ^{***}	2.51 ^{***}	4.77 ^{***}	2.29 ^{***}
Adj R ²	0.78	0.90	0.84	0.87
Yield				
Mean (kg/ha)	2262.79	2951.25	897.42	1932.28
CDVI	4.07	4.93	7.06	3.95
LGR	1.80	1.43	1.81	1.97
CGR	1.83 ^{***}	1.42 ^{***}	1.80 ^{***}	1.99 ^{***}
Adj R ²	0.87	0.74	0.69	0.90

Note: 1. *** representing significance at 1% level. NS- Non-Significant.

2. CDVI- Cuddy Della Valle Index, LGR- Linear Growth Rate, CGR- Compound Growth Rate, Adj R²- Adjusted Coefficient of Determination.

Study demonstrated Table 2 below that, area effect was most responsible factor for increasing production of paddy and gram revealing area contributing more than yield in production while, yield effect most powerful factor for increasing production of wheat and total foodgrains. The interaction effect found least responsible factor for all those crops showed least effect (<5%).

Table 2: Decomposition of production (%) for paddy, wheat, gram and total foodgrains in India during 2000-01 to 2019-20

Particulars	Paddy	Wheat	Gram	Foodgrains
Yield effect	36.73	62.78	13.09	80.87
Area effect	61.70	35.01	82.58	18.74
Interaction effect	1.57	2.21	4.33	0.39

State-wise growth and instability behaviour in India: Table 3a to 3c were the state-wise representation of growth and instability pattern in APY of paddy, wheat and gram in India during

2000-01 to 2019-20. States has given ranks (1 to 5) according to their maximum production during 2019-20. Table 3a, it was evident that Uttar Pradesh has found maximum average acreage share (13.25%) in India's area under paddy, whereas Punjab has highest average yield (3890.94 kg/ha) during study period. It was found that West Bengal, Uttar Pradesh and Panjab has very least instability in area, production and yield of paddy while, Odisha in area and Andhra Pradesh in yield falls within low instability states during study period. Andhra Pradesh found medium instability in area (22.07%) and production (22.06%) along with Odisha in production (25.07%) and yield (22.05%) which was highest instability among other states. This study also revealed surprise evident of having very low growth rates in APY of paddy, none of them falls under medium or high growth. Only Odisha has found both production and yield of paddy positive and highly significant growth rate of 3.65 percent at 1 percent level of significance. Andhra Pradesh has significantly highly declining growth rate of -2.79 percent and -1.53 percent in area and production, respectively at 1 percent level of significance. Only Uttar Pradesh and Odisha observed non-significant growth for area of paddy while West Bengal has significantly declining growth. From the results study reveals low growth-low risk of less desirable situation for major paddy producing states in India.

Table 3a: Growth performance and instability in APY of major paddy producing States of India during 2000-01 to 2019-20

States	West Bengal	Uttar Pradesh	Punjab	Andhra Pradesh	Odisha
Rank	1	2	3	4	5
Area					
Mean (million ha)	5.58 (12.81)	5.77 (13.25)	2.78 (6.37)	3.34 (7.68)	3.40 (7.80)
CDVI	4.07	4.53	2.18	22.07	7.94
LGR	-0.47	0.14	1.01	-2.45	0.02
CGR	-0.47 ^{***}	0.15 ^{NS}	1.01 ^{***}	-2.79 ^{***}	-0.0016 ^{NS}
Adj R ²	0.29	-0.02	0.88	0.31	-0.06
Production					
Mean (million tonnes)	14.80 (15.01)	12.62 (12.80)	10.830 (10.98)	10.51 (10.65)	5.73 (5.81)
CDVI	5.00	10.39	4.50	22.06	25.07
LGR	0.59	1.59	1.70	-1.43	3.63

CGR	0.60 ^{***}	1.61 ^{***}	1.73 ^{***}	-1.53 ^{***}	3.65 ^{***}
Adj R ²	0.29	0.43	0.83	0.10	0.34
Yield					
Mean (kg/ha)	2657.16	2184.09	3890.94	3188.71	1679.61
CDVI	2.32	7.95	3.65	6.50	22.05
LGR	1.07	1.48	0.70	1.32	3.58
CGR	1.07 ^{***}	1.46 ^{***}	0.71 ^{***}	1.30 ^{***}	3.65 ^{***}
Adj R ²	0.88	0.54	0.55	0.58	0.43

Note: 1. Figures in parentheses are percentage share to the India.

2. ^{***} representing significance at 1% level. NS- Non-Significant.

3. Ranks placed in the row according to the highest producing states during 2019-20.

4. CDVI- Cuddy Della Valle Index, LGR- Linear Growth Rate, CGR- Compound Growth Rate, Adj R²- Adjusted Coefficient of Determination.

Table 3b, it was evident that Uttar Pradesh has found maximum average acreage share (33.19%) in India's area under wheat whereas Punjab has highest average yield (4577.96kg/ha) during study period. All major wheat producing states (i.e., Uttar Pradesh, Madhya Pradesh, Punjab, Haryana and Rajasthan) showed low instability in APY except for production in Madhya Pradesh found medium instability (16.57%) which is highest among other states. Similarly, it was evident that all states showed positive and significant growth rates at 1 percent level of significance in APY of wheat except Madhya Pradesh in production showed medium growth rate of 7.95 percent which was higher than other states. Thus, again study reveals low growth-low risk of less desirable character for major wheat producing states.

Table 3b: Growth performance and instability in APY of major wheat producing States of India during 2000-01 to 2019-20

States	Uttar Pradesh	Madhya Pradesh	Punjab	Haryana	Rajasthan
Rank	1	2	3	4	5
Area					
Mean (million ha)	9.48 (33.19)	4.67 (16.34)	3.49 (12.20)	2.45 (8.57)	2.59 (9.07)
CDVI	1.80	8.30	0.80	2.33	9.36
LGR	0.43	3.35	0.16	0.62	2.29
CGR	0.43 ^{***}	3.40 ^{***}	0.17 ^{***}	0.63 ^{***}	2.38 ^{***}
Adj R ²	0.66	0.85	0.58	0.71	0.67

Production					
Mean (million tonnes)	27.50 (32.47)	10.73 (12.67)	15.97 (18.85)	10.63 (12.55)	7.84 (9.25)
CDVI	9.30	16.57	5.12	6.73	8.18
LGR	1.51	7.47	1.03	1.50	3.66
CGR	1.48 ^{***}	7.95 ^{***}	1.02 ^{***}	1.53 ^{***}	3.83 ^{***}
Adj R ²	0.45	0.88	0.57	0.63	0.87

Yield					
Mean (kg/ha)	2895.86	2181.68	4577.96	4334.67	2997.92
CDVI	8.98	9.64	5.16	5.87	4.47
LGR	1.09	4.33	0.86	0.90	1.41
CGR	1.04 ^{***}	4.40 ^{***}	0.85 ^{***}	0.90 ^{***}	1.42 ^{***}
Adj R ²	0.29	0.88	0.48	0.44	0.77

Note: 1. Figures in parentheses are percentage share to the India.

2. ^{***} representing significance at 1% level.

3. Ranks placed in the row according to the highest producing states during 2019-20.

4. CDVI- Cuddy Della Valle Index, LGR- Linear Growth Rate, CGR- Compound Growth Rate, Adj R²- Adjusted Coefficient of Determination.

From Table 3c, it was evident that Madhya Pradesh has found maximum average acreage share (34.76%) in India's area under gram as well as highest average yield (1021.32 kg/ha) during study period. It was found that Rajasthan has highest instability (32.53%) among other states for the production of gram. Only Madhya Pradesh has low instability in area (13.83%) and yield (11.17%) while Maharashtra for area (14.07%) of gram. All the major states (i.e., Rajasthan, Maharashtra, Uttar Pradesh and Karnataka) except Madhya Pradesh falls under medium instability for the yield of gram. It was found that all states showed positive but low growth rates for the yield of gram at 1 percent level of significance except Uttar Pradesh has positive but non-significant growth rate of 1.13 percent. Also, Uttar Pradesh remarked of negative but significant growth rate for area i.e., -2.83 percent and negative but non-significant growth for production i.e., -1.74 percent. For the production of gram in Maharashtra, Rajasthan and Karnataka has found highest but medium growth rates of 8.31, 7.91 and 7.47 percent with positive and highly significant at 1 percent level of significance. However, study revealed of having low growth-medium risk of least desirable character for major gram producing states.

Table 3c: Growth performance and instability in APY of major gram producing States of India during 2000-01 to 2019-20

States	Madhya Pradesh	Rajas- than	Maha- rashtra	Uttar Pradesh	Karnataka
Rank	1	2	3	4	5
Area					
Mean (million ha)	2.80 (34.76)	1.27 (15.79)	1.30 (16.08)	0.63 (7.78)	0.80 (9.88)
CDVI	13.83	25.13	14.07	17.33	17.72
LGR	1.21	4.46	5.07	-2.84	5.51
CGR	1.17***	4.78***	5.44***	-2.83***	6.19***
Adj R ²	0.14	0.51	0.82	0.41	0.78
Production					
Mean (million tonnes)	2.89 (39.18)	1.07 (14.46)	1.02 (13.85)	0.60 (8.17)	0.47 (6.41)
CDVI	17.48	32.53	25.63	28.18	20.11
LGR	3.53	7.48	7.38	-1.29	6.36
CGR	3.74***	7.91***	8.31***	-1.74 ^{NS}	7.47***
Adj R ²	0.58	0.65	0.75	0.02	0.77
Yield					
Mean (kg/ha)	1021.32	798.99	745.24	955.61	585.47
CDVI	11.17	18.83	15.06	20.74	16.79
LGR	2.54	2.96	2.67	1.40	1.17
CGR	2.54***	2.99***	2.72***	1.13 ^{NS}	1.20***
Adj R ²	0.63	0.41	0.51	0.04	0.09

Note: 1. Figures in parentheses are percentage share to the India.
 2. *** representing significance at 1% level. NS- Non-Significant.
 3. Ranks placed in the row according to the highest producing states during 2019-20.
 4. CDVI- Cuddy Della Valle Index, LGR- Linear Growth Rate, CGR- Compound Growth Rate, Adj R²- Adjusted Coefficient of Determination.

Growth performance of Chhattisgarh State during 2000-01 to 2019-20: The average percentage share in area of paddy and gram of Chhattisgarh state in India was increased from 9.04 and 3.00 percent (TE 2004-05) to 9.25 and 3.59percent(TE 2019-20), respectively while, the situation for wheat was inverse that it was decreased its share from 2.56percent to 0.35 percent. Similarly, for production, only paddy has found to increase its average percentage share from 5.17 (TE 2004-05) to 5.75 percent (TE 2019-20) while, wheat and gram has found decrease its average percentage share from 0.93 to 0.14 percent and 2.72 to 2.38 percent, respectively of Chhattisgarh in India. Study was

found drastically decline in area and production of wheat the decline was more than 75 percent, whereas gram has found increased both area and production more than 80 percent also production of paddy found increased (>50%) with minimum increase in area (7.12%) comparing all above from TE 2004-05 to TE 2019-20. The yield of paddy, wheat and gram of Chhattisgarh found increased by 47.33, 43.78 and 7.25 percent during TE 2004-05 to TE2019-20. It was depicted that yield of paddy and wheat has increasing growth trend, whereas gram has shown fluctuations in Chhattisgarh state, India has depicted increasing growth trend in yield of paddy, wheat and gram. While, the overall yield of paddy, wheat and gram of India has more than the Chhattisgarh state. Based on triennium ending, it was also evident that paddy has highest yield than wheat and gram has lowest, in Chhattisgarh whereas, wheat has found highest yield than paddy and gram has lowest for India during study period (See Appendix III- Chhattisgarh).

Table 4 below indicated that Chhattisgarh has average of 5.56, 0.48 and 3.30 percent share to the India's paddy wheat and gram production, respectively during study period whereas paddy has found highest average acreage share (8.94%) along with yield (1432.87 kg/ha). depicted that area of paddy has low instability (9.72%) while, production and yield observed medium instability during study period in Chhattisgarh state. Similarly, yield of wheat has observed low instability (11.40%) while, area and production observed very high instability revealing high risk associated with area of wheat. Area of gram has observed low instability (7.56%) while, production has observed very high instability prone to high risk and yield with medium instability during all study periods. The surprise result of very low growth rates (<5%) was observed in APY of paddy, wheat and gram during study period in Chhattisgarh state. Only production and yield of paddy was observed increased positively with highly significant growth rate of 4.02 and 3.68percent at 1 percent level of significance while, area showed non-significant result revealing very least increase in growth at 0.14 percent. Similarly, yield of wheat increased positively with highly significant growth rate of 2.43 percent at 1 percent level of significance, whereas area and production showed highly significant declining growth rate, this

decline was observed more in area than production of wheat. In case of gram, only area found positive and highly significant increasing growth rate of 4.21 percent at 1 percent level of significance, whereas production and yield found non-significant growth during study period. Thus, study reveals paddy, wheat and gram has low growth-high risk association which is least desirable for their production in Chhattisgarh state. Study found that, in Chhattisgarh, paddy has highest average yield than wheat followed by gram during study period.

Table 4: Growth rate dimensions and instability in APY of paddy, wheat and gram in Chhattisgarh state during 2000-01 to 2019-20

Particulars	Paddy	Wheat	Gram
	Area		
Mean (million ha)	3.89 (8.94)	0.39 (1.36)	0.25 (3.14)
CDVI	9.72	75.30	7.56
LGR	0.11	-11.92	4.05
CGR	0.14 ^{NS}	-11.67 ^{***}	4.21 ^{***}
Adj R ²	-0.05	0.46	0.91
Production			
Mean (million tonnes)	5.48 (5.56)	0.41 (0.48)	0.24 (3.30)
CDVI	19.50	80.91	56.06
LGR	3.58	-9.27	0.14
CGR	4.02 ^{***}	-8.26 ^{**}	1.57 ^{NS}
Adj R ²	0.51	0.26	-0.01
Yield			
Mean (kg/ha)	1432.87	1181.18	828.07
CDVI	18.80	11.40	27.55
LGR	3.19	2.44	1.31
CGR	3.68 ^{***}	2.43 ^{***}	0.70 ^{NS}
Adj R ²	0.47	0.61	-0.04

Note: 1. Figures in parentheses are percentage share of area and production to the India.

2. ^{***}, ^{**} and ^{*} representing significance at 1%, 5% and 10% level. NS- Non-Significant.

3., CDVI- Cuddy Della Valle Index, LGR- Linear Growth Rate, CGR- Compound Growth Rate, Adj R²- Adjusted Coefficient of Determination.

Growth and instability in Raipur: Paddy had highest average percentage share in area and production with average yield of 1452.86kg/ha to the Chhattisgarh state followed by yield of wheat and gram during study period. Paddy revealed predominant crop grown in Raipur. Table 5a depicted very low instability in area (1.56%) of paddy, while production and yield revealed

medium instability. Similarly, Wheat and gram falls under medium instability in APY. All the crops had high risk associated in production followed by yield and area. Positive but very low increase of annual compound growth rate observed in area of paddy (0.35%) and wheat (0.25), while gram (-0.22) had declined growth in area. Growth rates in production of paddy (4.92%) and wheat (3.52%) found highly increased significantly, while gram (1.65%) showed non-significant increased. Growth rates in yield of paddy, wheat and gram recorded positive and significantly increased to 4.54, 3.27 and 1.97 per cent, respectively. At overall, it reveals that increased in production of paddy, wheat and gram in Raipur district was contributed more by the increased in per hectare output than area of respective crops. Thus, study also reveals low growth-medium risk associated which is less desirable for production of paddy, wheat and gram in Raipur.

Table 5a: Growth rate dimensions and instability in APY of paddy, wheat and gram in Raipur during 2000-01 to 2019-20

Particulars	Paddy	Wheat	Gram
	Area		
Mean (thousand ha)	533.44 (13.71)	8.34 (2.14)	7.70 (3.08)
CDVI	1.56	13.17	19.99
LGR	0.34	0.15	-0.36
CGR	0.35 ^{***}	0.25 ^{NS}	-0.22 ^{NS}
Adj R ²	0.62	-0.04	-0.05
Production			
Mean (thousand tonnes)	778.94 (14.21)	12.35 (3.01)	7.24 (3.02)
CDVI	22.65	16.51	33.54
LGR	4.08	3.37	1.65
CGR	4.92 ^{***}	3.52 ^{***}	1.74 ^{NS}
Adj R ²	0.49	0.58	0.01
Yield			
Mean (kg/ha)	1452.86	1489.89	927.54
CDVI	22.19	17.34	25.08
LGR	3.77	3.22	2.11
CGR	4.54 ^{***}	3.27 ^{***}	1.97 [*]
Adj R ²	0.46	0.52	0.12

Note: 1. Figures in parentheses are percentage share of area and production of paddy, wheat and gram to the Chhattisgarh state.

2. ^{***}, ^{**} and ^{*} representing significance at 1%, 5% and 10% level. NS- Non-Significant.

3. CDVI- Cuddy Della Valle Index, LGR- Linear Growth Rate, CGR- Compound Growth Rate, Adj R²- Adjusted Coefficient of Determination.

Growth and instability in Mahasamund: The average percentage share in area and production was highest for paddy followed by wheat and very least for gram of Mahasamund district to the Chhattisgarh state during study period but yield of wheat was observed highest i.e., 1532.70 kg/ha among other crops. It reveals paddy were predominantly crop grown in district. It was observed from Table 5b that only area of paddy has low instability (1.86%) while, production and yield fall under medium instability during study period.

Table 5b: Growth rate dimensions and instability in APY of paddy, wheat and gram in Mahasamund during 2000-01 to 2019-20

Particulars	Paddy	Wheat	Gram
	Area		
Mean (thousand ha)	262.98 (6.76)	1.49 (0.38)	0.24 (0.09)
CDVI	1.86	29.86	32.34
LGR	1.05	-1.36	-5.56
CGR	1.06 ^{***}	-1.19 ^{NS}	-5.62 ^{***}
Adj R ²	0.92	0.01	0.53
Production			
Mean (thousand tonnes)	361.50 (6.59)	2.22 (0.55)	0.20 (0.08)
CDVI	23.97	29.25	34.75
LGR	4.09	0.11	-3.88
CGR	5.33 ^{***}	0.32 ^{NS}	-4.50 ^{***}
Adj R ²	0.47	-0.05	0.30
Yield			
Mean (kg/ha)	1358.86	1532.70	865.72
CDVI	24.02	21.64	26.72
LGR	3.20	1.36	1.43
CGR	4.22 ^{***}	1.52 ^{NS}	1.19 ^{NS}
Adj R ²	0.36	0.09	0.00

Note: 1. Figures in parentheses are percentage share of area and production of paddy, wheat and gram to the Chhattisgarh state.

2. ^{***}, ^{**} and ^{*} representing significance at 1%, 5% and 10% level. NS- Non-Significant.

3. CDVI- Cuddy Della Valle Index, LGR- Linear Growth Rate, CGR- Compound Growth Rate, Adj R²- Adjusted Coefficient of Determination.

Also, surprisingly APY of wheat as well as yield of paddy, wheat and gram has observed medium instability. Again, gram observed high instability in area (32.34%) and production (34.75%) depicted high risk associated with the production. It was found that APY of paddy, wheat and gram has fall under

low growth rate in Mahasamund. Surprisingly, paddy has found highly positive and significant increased growth rate in production, yield and area i.e., 5.33, 4.22 and 1.06 percent, respectively at 1 percent level of significance. Again, surprising result was observed for that APY of wheat found non-significant with declining growth rate in area. Result of area and production of gram has also surprise that it revealed highly and significantly declining growth rate at 1 percent level of significance while, yield resulted in non-significant growth. Thus, study revealed the low growth-medium risk associated with the production of wheat and gram which is less desirable except paddy.

Growth and instability in Dhamtari: The average percentage share in area and production was highest for paddy followed by gram and very least for wheat of Dhamtari district to the Chhattisgarh state during study period however the average yield of paddy was observed highest i.e., 2083.46 kg/ha among other selected crops. Thus, it was revealed the paddy-gram cropping pattern followed in district based on area and production but the average yield showed higher for wheat than gram. It was found from Table 5c that area and production of wheat and gram has highest (more than 50%) instability revealing very high risk associated with both the crops in Dhamtari district. APY of paddy depicting low-medium instability while least observed in area (8.65%). However, yield of paddy, wheat and gram found medium instability. Surprise result was found for APY of paddy, wheat and gram that crops depicted low growth rate except production of paddy. Similarly, APY of paddy has positive and highly significant growth rate at 1 percent level of significance of which production showed highest i.e., 6.23 percent. area and production of wheat found highly declining but non-significant growth while, yield appears positive and highly significant growth of 3.43 percent at 1 percent level of significance. Area and yield observed non-significant results for gram in Dhamtari district while production has positive and significant growth result of 3.17 percent at 5 percent level of significance. Thus, overall study revealed of having very low growth-very high risk associated with the wheat and gram crops which is least desirable for production of these crops.

Table 5c: Growth rate dimensions and instability in APY of paddy, wheat and gram in Dhamtari during 2000-01 to 2019-20

Particulars	Paddy	Wheat	Gram
	Area		
Mean (thousand ha)	163.77 (4.21)	2.03 (0.52)	9.08 (3.58)
CDVI	8.65	54.26	53.31
LGR	1.46	-4.54	2.19
CGR	1.46***	-5.19 ^{NS}	2.19 ^{NS}
Adj R ²	0.49	0.22	0.02
Particulars	Production		
	Paddy	Wheat	Gram
Mean (thousand tonnes)	351.19 (6.40)	2.57 (0.63)	9.02 (3.71)
CDVI	23.35	61.49	58.75
LGR	5.60	-1.16	3.87
CGR	6.23***	-1.93 ^{NS}	3.71**
Adj R ²	0.68	-0.01	0.10
Particulars	Yield		
	Paddy	Wheat	Gram
Mean (kg/ha)	2083.46	1329.61	984.51
CDVI	17.59	9.91	22.94
LGR	4.31	3.31	1.65
CGR	4.69***	3.43***	1.50 ^{NS}
Adj R ²	0.68	0.79	0.07

Note: 1. Figures in parentheses are percentage share of area and production of paddy, wheat and gram to the Chhattisgarh state.

2. ***, ** and * representing significance at 1%, 5% and 10% level. NS- Non-Significant.

3. CDVI- Cuddy Della Valle Index, LGR- Linear Growth Rate, CGR- Compound Growth Rate, Adj R²- Adjusted Coefficient of Determination.

Growth and instability in Durg: The average percentage share in area and production was found highest under gram followed by paddy and wheat of Durg district to the Chhattisgarh state during study period however as always, the yield of paddy was observed highest i.e., 1483.50 kg/ha than wheat and gram. Thus, it was revealed that gram was dominant in district based on area and production but the average yield surprisingly showed very low i.e., 899.71 kg/ha than wheat and paddy. Table 5d depicted overall instability found highest in production and yield of paddy, wheat and gram, while instability was even more in case of gram for production (39.68%) and yield (31.41%). Instability in area of paddy (2.30%) found lowest. Thus, overall paddy and wheat falls under medium risk associated for their production in Durg district. Growth rates in area and production of paddy,

wheat and gram recorded highly significant and positively increased during study period. Growth rate in production of paddy (4.80%) and wheat (5.73%) recorded highest. The result was highly surprise by gram despite it was dominant in Durg district in terms of highest share, there was decline in growth rate in yield (-0.37). This was greatly attributed to low irrigation facilities, underutilized high yielding Varieties (HYVs) and predominance of following traditional way of cultivation practices. Thus, study also revealed low growth-high risk associated in production only in case of gram, which is very least desirable situation in Durg district, while paddy and wheat associated low growth-medium risk.

Table 5d: Growth rate dimensions and instability in APY of paddy, wheat and gram in Durg during 2000-01 to 2019-20

Particulars	Paddy	Wheat	Gram
	Area		
Mean (thousand ha)	464.64 (11.94)	22.57 (5.79)	99.85 (39.94)
CDVI	2.30	11.55	9.90
LGR	0.75	2.80	3.80
CGR	0.74***	2.85***	4.14***
Adj R ²	0.79	0.68	0.83
Particulars	Production		
	Paddy	Wheat	Gram
Mean (thousand tonnes)	695.90 (12.70)	21.54 (5.25)	90.37 (37.66)
CDVI	29.46	13.24	39.68
LGR	3.94	5.08	4.10
CGR	4.80***	5.73***	3.74*
Adj R ²	0.14	0.18	0.49
Particulars	Yield		
	Paddy	Wheat	Gram
Mean (kg/ha)	1483.50	935.97	899.71
CDVI	28.51	11.21	31.41
LGR	3.20	2.67	1.04
CGR	4.04**	2.80***	-0.37 ^{NS}
Adj R ²	0.27	0.66	-0.05

Note: 1. Figures in parentheses are percentage share of area and production of paddy, wheat and gram to the Chhattisgarh state.

2. ***, ** and * representing significance at 1%, 5% and 10% level. NS- Non-Significant.

3. CDVI- Cuddy Della Valle Index, LGR- Linear Growth Rate, CGR- Compound Growth Rate, Adj R²- Adjusted Coefficient of Determination.

Table 6, demonstrated the relative contribution of yield and area and their interaction in the production

of paddy, wheat and gram for selected four districts of Chhattisgarh plains during 2000-01 to 2019-20. It clearly evident that yield effect of paddy was strong positive and higher than that of area and their interaction which is most responsible factor for increasing production of paddy in all the selected districts of Chhattisgarh plains. For increasing wheat production, area effect was most important factor responsible in all the selected districts of Chhattisgarh plains except in case of Dhamtari, yield effect was more dominant affecting increase of wheat production which was due positive and significant growth in yield of wheat. In case of gram, only Raipur and Durg has found strong yield effect responsible factor for increasing production, while Mahasamund and Dhamtari had strong area effect responsible factor for increasing gram production. It was also observed that Mahasamund has minimal (very least) yield effect (0.02%).

Table 6: Decomposition of production growth for paddy, wheat and gram in districts of Chhattisgarh plains during 2000-01 to 2019-20

Particulars	Paddy			
	Raipur	Mahasamund	Dhamtari	Durg
Yield effect	79.21	69.48	1665.97	124.37
Area effect	21.44	27.96	-1397.25	-22.59
Interaction effect	-0.65	2.56	-168.72	-1.78
Particulars	Wheat			
	Raipur	Mahasamund	Dhamtari	Durg
Yield effect	-29.80	-722.86	68.01	-14.82
Area effect	154.90	1249.34	53.08	117.65
Interaction effect	-25.10	-426.48	-21.09	-2.82
Particulars	Gram			
	Raipur	Mahasamund	Dhamtari	Durg
Yield effect	219.46	0.02	19.23	169.25
Area effect	-73.15	94.57	69.78	-137.94
Interaction effect	-46.32	5.41	11.00	68.69

CONCLUSION

From the above results during study period 2000-01 to 2019-20, some concluding points were find out that India’s production of paddy, wheat and gram were depicted increasing trend. The average percentage share of paddy, wheat and gram in area and production has slow but steady increase to the total foodgrains of India. Production of gram has highest growth rate than paddy and wheat

also have highest area effect most responsible in increasing production of gram in India. Production growth can be achieved by increase in the irrigated area, adopting HYVs and technological advances such as quality seeds, bio-fertilizers and nutrient managements. For major paddy and wheat producing states of the India, study reveals low growth-low risk association depicting less desirable situation for their production while, for gram reveals low growth-medium risk association. Instability in production is due to variability in both area and yield of different crops. Chhattisgarh has increased its share in APY of paddy, wheat and gram to the India. Only paddy has positively significant growth in production in State. Raipur, Mahasamund, Dhamtari and Durg mostly revealed low growth-medium risk association which is less desirable for production of paddy, wheat and gram in those districts. Low growth rate situation under the district’s revealed producers have yet to fully utilize of resources in the production of these crops. In the decomposition analysis, area effect was more strongly responsible for wheat and gram, whereas yield effect for paddy in the production of these crops in selected districts of Chhattisgarh plains. Producers focus should need towards advanced production technologies and high yield varieties (HYVs) and better irrigation facilities for boosting cereals and pulses crops production. Policy measures are needed to reduce the instability in cereals and pulses crops. Overall, the speedy industrialization side by side marginalization of land holding in the State had moved producers away from the cultivable land. Thus, policy arrangement should built in this view. Similarly, Government needs to look into stabilizing prices with enough marketing support, farmers input-output markets and making highest possible procurement from the farmers.

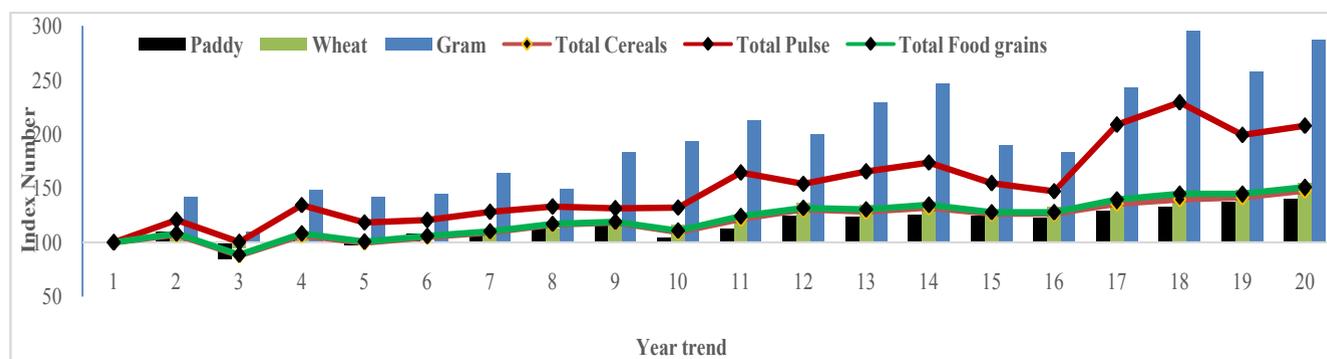
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APPENDIX I



Source: Author’s calculation data compiled from Directorate of Economics & Statistics (DAC&FW) Govt. of India.

Fig. 1: Production trend of paddy, wheat, gram, total cereals, total pulses and foodgrains in India during 2000-01 to 2019-20. (Base year 2000-01).

APPENDIX II

Percentage share (Triennium ending- TE) of paddy, wheat and gram to the total foodgrain in India during 2000-01 to 2019-20

Particulars	Paddy	Wheat	Gram	Foodgrains
	Area			
TE 2004-05	35.17	21.87	5.50	119.13
TE 2009-10	35.68	22.88	6.41	122.74
TE 2014-15	35.39	24.84	7.21	123.37
TE 2019-20	34.77	23.87	7.88	126.15
Production				
TE 2004-05	41.53	35.23	2.63	195.44
TE 2009-10	41.70	35.13	2.97	227.79
TE 2014-15	40.99	35.64	3.32	258.06
TE 2019-20	40.12	35.88	3.73	289.24

Note: Foodgrains column- Area (million hectare) and Production (million tonnes)

Source: Author’s calculation (TE-Triennium Ending) data compiled from Directorate of Economics & Statistics (DAC&FW) Govt. of India.

APPENDIX III

Average growth and share (Triennium ending- TE) in APY of paddy, wheat and gram in Chhattisgarh state and India during 2000-01 to 2019-20.

Particulars	Chhattisgarh			India		
	Paddy	Wheat	Gram	Paddy	Wheat	Gram
Area (Million Hectares)						
TE 2004-05	3.79 (9.04)	0.67 (2.56)	0.20 (3.00)	41.89	26.06	6.56
TE 2009-10	3.72 (8.49)	0.64 (2.30)	0.24 (3.10)	43.79	28.08	7.87
TE 2014-15	3.80 (8.70)	0.10 (0.33)	0.27 (3.08)	43.67	30.65	8.90
TE 2019-20	4.06 (9.25)	0.11 (0.35)	0.36 (3.59)	43.86	30.11	9.94
Production (Million Tonnes)						
TE 2004-05	4.19 (5.17)	0.64 (0.93)	0.14 (2.72)	81.16	68.85	5.14
TE 2009-10	4.64 (4.89)	0.68 (0.85)	0.21 (3.11)	94.99	80.02	6.76
TE 2014-15	6.55 (6.19)	0.14 (0.16)	0.26 (3.09)	105.79	91.96	8.56
TE 2019-20	6.67 (5.75)	0.15 (0.14)	0.26 (2.38)	116.04	103.78	10.80
Yield (Qtl/Ha)						
TE 2004-05	1107	980	717	1935	2642	781
TE 2009-10	1247	1062	862	2168	2850	858
TE 2014-15	1724	1395	958	2423	3004	962
TE 2019-20	1631	1409	769	2646	3447	1087

Note: Figures in parentheses representing percentage share of paddy, wheat and gram to the total India.

Source: Author's calculation data compiled from Directorate of Economics & Statistics Govt. of Chhattisgarh and Directorate of Economics & Statistics (DAC&FW) Govt. of India.

