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Growth trends in area, production and productivity of major cereal crops (paddy, maize and wheat) in Chhattisgarh: A compound annual growth rate analysis (2013-14 to 2022-23)

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Abstract

This study examines the growth performance of three major cereal crops - paddy, maize, and wheat grown in Chhattisgarh during the period 2013-14 to 2022-23, using Compound Annual Growth Rate (CAGR) analysis of area, production, and productivity. Secondary time-series data were obtained from the Directorate of Economics and Statistics, Government of Chhattisgarh, and CAGR values were estimated using the log-linear (exponential) growth function, with statistical significance tested through the corresponding t-statistic. The results reveal that paddy area expanded at a significant annual rate of 1.17 per cent, while its production and productivity grew at non-significant rates of 2.23 and 3.62 per cent respectively, indicating year-to-year instability largely attributable to erratic rainfall. Maize recorded the most robust and consistent performance among the three crops, with area, production, and productivity increasing at highly significant rates of 1.49, 9.43, and 7.82 per cent per annum, reflecting the crop's growing acceptability, improved hybrid seed adoption, and diversification away from traditional paddy cultivation. Wheat area and production expanded significantly at 4.54 and 5.16 per cent per annum, but productivity showed a marginal and statistically non-significant decline of 0.59 per cent, suggesting near-stagnant yield levels despite area expansion. The study concludes that while all three cereals exhibited area expansion, maize emerged as the most dynamic crop in terms of production and productivity growth, whereas paddy and wheat require targeted technological and policy interventions to translate area growth into sustained productivity gains. Suggestions for climate-resilient varieties, irrigation development, and diversification strategies are offered to strengthen cereal crop performance in the state.

Keywords: CAGR, growth rate, paddy, maize, wheat

Introduction

Agriculture continues to be the backbone of the Indian economy and the principal source of livelihood for the majority of the rural population, and this holds especially true for the state of Chhattisgarh, which is popularly known as the "Rice Bowl of India" (Directorate of Economics and Statistics, 2022-23). Cereal crops, particularly paddy, maize, and wheat, occupy a dominant position in the cropping pattern of the state owing to its favourable agro-climatic conditions, fertile alluvial and red-lateritic soils, and adequate monsoon rainfall suited to kharif and rabi cultivation (Patel & Chandrakar, 2019) ^[5]. Paddy remains the principal kharif crop of Chhattisgarh, occupying the largest share of the gross cropped area, while maize has steadily emerged as an important crop of both kharif and rabi seasons owing to its multiple uses in food, feed, and industrial applications (Sahu & Mishra, 2018; Verma & Tiwari, 2021) ^[6, 10]. Wheat, though a comparatively minor rabi cereal in the state, plays a supplementary role in strengthening food security and crop diversification (Sharma & Sisodiya, 2017) ^[7].

Growth analysis of area, production, and productivity over time is an essential tool in agricultural economics, as it helps in understanding whether the growth in output has been driven by expansion of cultivated area, improvement in yield, or a combination of both (Kumar, Sharma & Singh, 2021) ^[3]. Such analysis also assists policymakers in identifying crop-specific bottlenecks and formulating appropriate strategies for resource allocation, research investment,

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and extension support (Singh & Kumar, 2020) [8]. The Compound Annual Growth Rate (CAGR) is a widely used and statistically robust measure that captures the average annual rate of change of a variable over a specified time period, smoothing out year-to-year fluctuations that are common in agricultural production due to weather variability, pest incidence, and market factors (Nishad & Verma, 2020) [4].

The present study was undertaken to examine and compare the growth performance of paddy, maize, and wheat crops in Chhattisgarh over the ten-year period from 2013–14 to 2022–23, with the specific objectives of estimating the CAGR of area, production, and productivity of each crop, testing the statistical significance of the estimated growth rates, and drawing policy-relevant conclusions regarding the relative performance of these three important cereal crops.

Materials and Methods

Study area

The present study is based on the state of Chhattisgarh, an important cereal-growing state of central India, known for its dominance in paddy cultivation and increasing diversification towards maize and wheat in recent years.

Data sources and period of study

The study is based entirely on secondary data pertaining to area, production, and productivity of paddy, maize, and wheat crops in Chhattisgarh for a period of ten years, from 2013-14 to 2022-23. The requisite data were collected from the published reports of the Directorate of Economics and Statistics, Government of Chhattisgarh (2022-23).

Analytical Tools

The compound annual growth rate (CAGR) of area, production, and productivity of each crop was estimated by fitting the exponential (log-Linear) growth function of the following form:

$$Y = a \cdot b^t \cdot e$$

which, on logarithmic transformation, reduces to the linear form:

$$\ln(Y) = \ln(a) + t \cdot \ln(b) + e$$

where Y represents the dependent variable (area, production, or productivity) in year t, a is the intercept, b is the regression coefficient, t denotes the time variable (year), and e is the random error term. The compound annual growth rate was then computed from the estimated regression coefficient (b) using the relation:

$$\text{CAGR (\%)} = (\text{Antilog}(b) - 1) \times 100$$

The statistical significance of the estimated growth rates was tested using the t-test, and the corresponding p-values were used to classify the growth rates as significant at the 1 per cent (***), 5 per cent (**), or 10 per cent (*) level, or as statistically non-significant (NS).

Results and Discussion

Growth Performance of paddy crop

The area under paddy cultivation in Chhattisgarh increased from 3987.72 thousand hectares in 2013-14 to 4335.20 thousand hectares in 2022-23, registering a statistically significant compound annual growth rate of 1.17 per cent. Paddy production increased from 7102.73 thousand metric tonnes to 11,224.48 thousand metric tonnes over the same period, with an estimated CAGR of 2.23 per cent; however, this growth was

found to be statistically significant, reflecting considerable year-to-year fluctuation in production, most notably the sharp dip observed in 2015-16 and 2017-18. Productivity of paddy improved from 1781 kg/ha to 2589 kg/ha, corresponding to a CAGR of 3.62 per cent, which was also statistically non-significant. These results suggest that although paddy continues to dominate the cropping pattern of the state in terms of area, its production and productivity growth remain unstable, largely on account of dependence on monsoon rainfall, limited irrigation coverage in certain districts, and periodic weather aberrations.

Table 1: CAGR of Area, Production and Productivity of Paddy Crop in Chhattisgarh (2013-14 to 2022-23)

S. No.	Year	Area (000 ha)	Production (000 MT)	Productivity (kg/ha)
1	2013-14	3,987.72	7,102.73	1,781.00
2	2014-15	4,035.70	7,977.75	1,976.00
3	2015-16	3,959.75	5,154.33	1,301.00
4	2016-17	4,052.59	8,793.27	2,169.00
5	2017-18	3,976.63	5,749.04	1,445.00
6	2018-19	4,141.38	6,509.43	1,571.00
7	2019-20	4,266.02	8,569.37	2,008.00
8	2020-21	4,339.26	9,249.69	2,131.00
9	2021-22	4,348.23	8,825.66	2,029.00
10	2022-23	4,335.20	11,224.48	2,589.00
	CAGR (%)	1.17*	2.23 *	3.62 ^{NS}
	P-Value	0.001	0.064	0.125

Source: Directorate of Economics and statistics, 2022-23

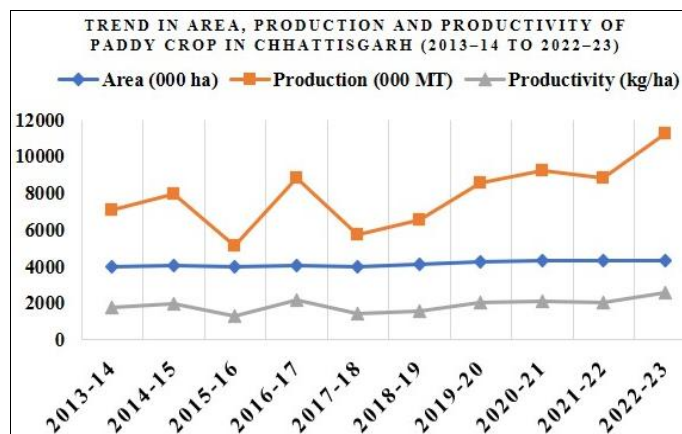


Fig 1: Trend in Area, Production and Productivity of Paddy Crop in Chhattisgarh (2013-14 to 2022-23)

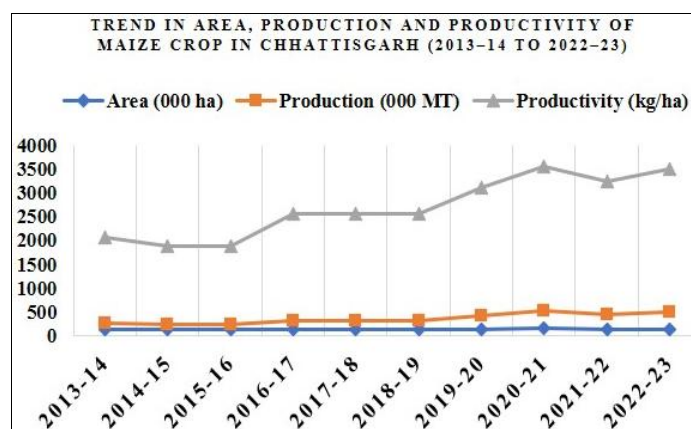
Growth Performance of maize crop

Maize exhibited the most consistent and dynamic growth among the three cereal crops studied. The area under maize increased from 123.59 thousand hectares in 2013-14 to 139.18 thousand hectares in 2022-23, at a significant CAGR of 1.49 per cent. Production increased markedly from 254.48 thousand metric tonnes to 489.23 thousand metric tonnes, registering a highly significant growth rate of 9.43 per cent per annum. Productivity also improved substantially from 2060 kg/ha to 3520 kg/ha, with a highly significant CAGR of 7.82 per cent. This strong and statistically significant performance across all three parameters indicates that the growth in maize production has been driven largely by yield improvement rather than area expansion alone, pointing towards the increasing adoption of improved and hybrid maize varieties, better agronomic practices, and growing market demand for maize as food, feed, and industrial raw material in the state.

Table 2: CAGR of Area, Production and Productivity of Maize Crop in Chhattisgarh (2013-14 to 2022-23)

S. No.	Year	Area (000 ha)	Production (000 MT)	Productivity (kg/ha)
1	2013-14	123.59	254.484	2,059.00
2	2014-15	125.074	235.014	1,879.00
3	2015-16	126.356	237.676	1,881.00
4	2016-17	120.547	309.324	2,566.00
5	2017-18	119.617	306.937	2,566.00
6	2018-19	118.047	303.145	2,568.00
7	2019-20	130.433	406.821	3,119.00
8	2020-21	147.172	522.755	3,552.00
9	2021-22	132.301	430.904	3,257.00
10	2022-23	139.183	489.237	3,515.00
	CAGR (%)	1.49**	9.43***	7.82***
	P-Value	0.047	0.001	0.001

Source: Directorate of Economics and statistics, 2022-23

**Fig 2:** Trend in Area, Production and Productivity of Maize Crop in Chhattisgarh (2013-14 to 2022-23)

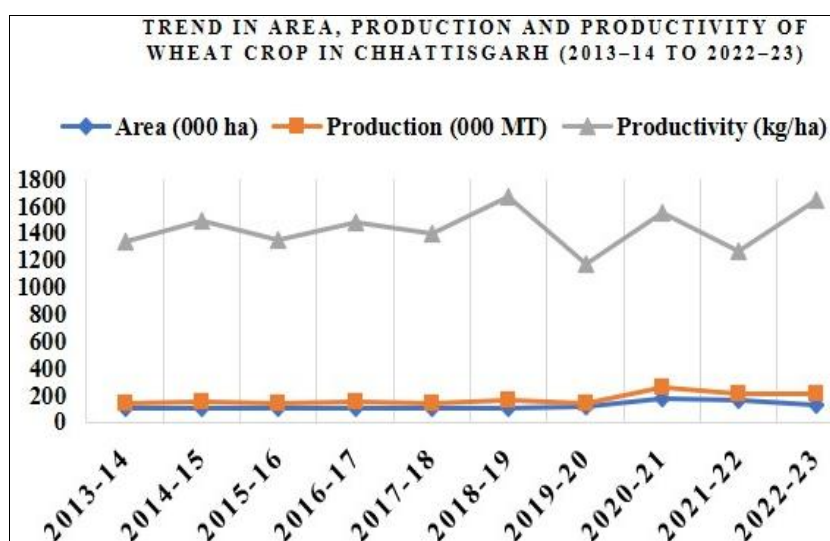
Growth Performance of wheat crop

The area under wheat cultivation increased from 105.033 thousand hectares in 2013-14 to 125.183 thousand hectares in 2022-23, registering a significant CAGR of 4.54 per cent, the highest area growth rate among the three crops studied. Wheat production also increased significantly, from 140.756 thousand metric tonnes to 206.899 thousand metric tonnes, at a CAGR of 5.15 per cent. However, productivity remained nearly stagnant, showing a marginal and statistically non-significant negative growth of 0.56 per cent, with yield fluctuating between 1340 kg/ha and 1652 kg/ha over the study period. This pattern indicates that the observed growth in wheat production was driven predominantly by area expansion rather than genuine yield improvement, and highlights a need for greater attention to yield-enhancing technologies, timely sowing, and irrigation management for wheat cultivation in the state.

Table 3: CAGR of Area, Production and Productivity of Wheat Crop in Chhattisgarh (2013-14 to 2022-23)

S. No.	Year	Area (000 ha)	Production (000 MT)	Productivity (kg/ha)
1	2013-14	105.033	140.756	1,340.00
2	2014-15	103.195	153.321	1,485.00
3	2015-16	105.785	142.329	1,345.00
4	2016-17	102.114	151.078	1,479.00
5	2017-18	102.195	141.642	1,386.00
6	2018-19	99.925	166.979	1,671.00
7	2019-20	116.274	135.888	1,168.00
8	2020-21	167.497	259.51	1,549.00
9	2021-22	160.268	203.833	1,271.00
10	2022-23	125.183	206.899	1,652.00
	CAGR (%)	4.54**	5.16**	0.59 ^{NS}
	P-Value	0.024	0.023	0.68

Source: Directorate of Economics and statistics, 2022-23

**Fig 3:** Trend in Area, Production and Productivity of Wheat Crop in Chhattisgarh (2013-14 to 2022-23)

Comparative Growth performance

A comparison of the growth rates across the three crops reveals distinct patterns of agricultural transformation in Chhattisgarh. Wheat recorded the highest rate of area expansion (4.54%), followed by maize (1.49%) and paddy (1.17%). In terms of production growth, maize outperformed both paddy and wheat with a highly significant CAGR of 9.43 per cent, compared to non-significant growth of 4.83 per cent for paddy and significant growth of 5.15 per cent for wheat. Most notably, maize was the

only crop to record a highly significant and substantial productivity growth (7.82%), while paddy showed non-significant productivity improvement (3.62%) and wheat showed a marginal productivity decline (-0.56%, non-significant). These findings collectively indicate that maize has emerged as the most dynamic and technologically responsive cereal crop in the state during the study period, whereas the growth in paddy and wheat has been comparatively driven more by area expansion than by yield improvement.

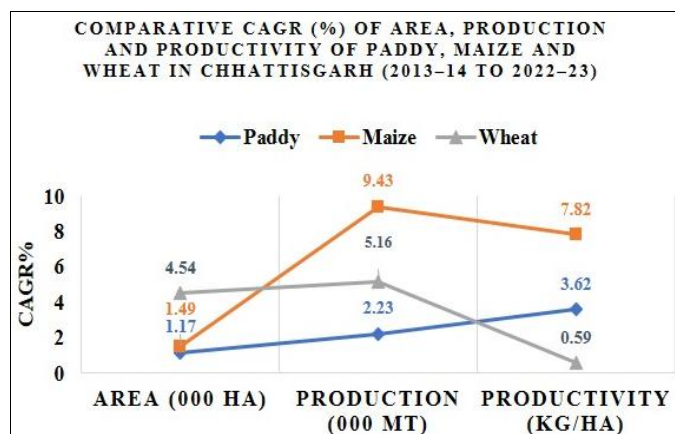


Fig 4: Comparative CAGR (%) of Area, Production and Productivity of Paddy, Maize and Wheat in Chhattisgarh (2013-14 to 2022-23)

Conclusion

The study concludes that among the three major cereal crops of Chhattisgarh, maize registered the most impressive and statistically robust growth performance in area, production, and productivity during 2013-14 to 2022-23, reflecting a gradual shift of farmers towards more remunerative and input-responsive crops. Paddy, despite remaining the dominant cereal crop of the state in terms of area, exhibited unstable and statistically non-significant growth in production and productivity, underscoring its continued vulnerability to rainfall variability. Wheat recorded significant growth in area and production but showed stagnation in productivity, suggesting that expansion has occurred largely through area rather than technological improvement. Overall, the findings highlight the need for differentiated crop-specific strategies: consolidating maize's growth momentum, stabilizing paddy productivity through improved water management, and enhancing wheat yields through better varietal and agronomic interventions.

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