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Spatiotemporal dynamics of paddy cultivation across agroclimatic zones of Chhattisgarh

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Abstract

Rice is a major staple crop contributing significantly to food security and rural livelihoods in India, particularly in Chhattisgarh, known as the “Rice Bowl of Central India.” The present study examines the spatiotemporal trends in the area, production, and productivity of rice across different agroclimatic zones of the state over the period 2012–13 to 2023–24, based on secondary data obtained from the Directorate of Economics and Statistics and the Government of Chhattisgarh agricultural portal. A linear regression model was employed to analyze growth patterns and regional variations. The results reveal significant inter-district and inter-zonal disparities, with the Chhattisgarh Plains zone showing relatively better performance driven by both area expansion and productivity gains, while the Northern Hills and Bastar Plateau zones exhibited limited or declining trends in area, with production growth primarily supported by improvements in productivity in select districts. Overall, the findings highlight the influence of region-specific factors such as irrigation access, technological adoption, and institutional support on rice production dynamics. The study underscores the need for targeted, location-specific interventions focusing on improving productivity through efficient resource use, climate-resilient technologies, and strengthened extension services to ensure sustainable rice production and long-term food security.

Keywords: Rice cultivation, trend analysis, agroclimatic zones, productivity

Introduction

Agriculture plays a vital role in the Indian economy by ensuring food security, generating employment, and supporting the livelihoods of a large rural population. A sizable section of India's population depends on agriculture and allied sectors for its livelihood and subsistence. One of the most important staple crops among the food grain crops grown in India is rice (*Oryza sativa* L.), which accounts for a sizable portion of the nation's overall cultivated area and food grain production. Millions of people rely on rice to meet their nutritional needs, and it makes a significant contribution to the country's food security. Due to the adoption of improved varieties, the expansion of irrigation facilities, and the development of agricultural technologies, India's rice acreage, production, and productivity have gradually increased over time (Chand *et al.*, 2019; Birthal *et al.*, 2020; Kumar *et al.*, 2021) ^[3, 1, 4].

Chhattisgarh is one of the major rice-producing states in India and is popularly known as the “Rice Bowl of Central India.” The majority of rural residents rely on farming as their primary source of income, and agriculture is the foundation of the state's economy. Fertile soils, sufficient rainfall, and large lowland areas ideal for rice cultivation are

among the state's favourable agroclimatic conditions for paddy cultivation. Rice is the main crop grown during the kharif season and makes up around two-thirds of the state's total farmed area. The state's predominance of rice growing indicates its importance to the farming community's economic stability and food security (Netam *et al.*, 2017; Bhuarya *et al.*, 2018; Kurrey *et al.*, 2023) ^[7, 2, 6].

Chhattisgarh, located in central India, is also rich in minerals and natural resources. Northern Hills, Chhattisgarh Plains, and Bastar Plateau are the three agroclimatic zones that make up its 27 districts and 135,192 km². Rain-fed agriculture, the state's main source of income and economic foundation, is supported by its tropical, humid environment, which is influenced by the Tropic of Cancer and abundant water resources. Its lifeline is the Mahanadi River, which receives 1279 mm of rain on average each year. About 44 percent of the area is covered by forests, which enhance resources and biodiversity. (Thakur *et al.*, 2025) ^[9].

The Chhattisgarh Plains zone contributes the greatest amount of paddy area and output among the three agroclimatic zones—Northern Hills, Chhattisgarh Plains, and Bastar Plateau—because of its advantageous climate, fertile alluvial soils, and comparatively better irrigation

infrastructure. The Northern Hills zone, on the other hand, is distinguished by undulating terrain and relatively lower agricultural production, whereas the Bastar Plateau zone is dominated by tribal agriculture and mostly rain-fed farming systems (Sumer *et al.*, 2022; Kurrey *et al.*, 2023) ^[8, 6]. Chhattisgarh's paddy production, productivity, and area have all changed significantly during the past ten years. The increase of irrigation infrastructure, government agricultural policy, technical advancements, and climate variability are the primary causes of these shifts. According to trend analysis studies, the state's total paddy output has demonstrated a positive growth trend over time, in spite of variations brought on by rainfall variability (Wasnik *et al.*, 2022; Sumer *et al.*, 2022) ^[10, 8]. Due to more efficient use of enhanced seed types and contemporary farming techniques, the Chhattisgarh Plains zone has seen comparatively higher productivity development. However, due to increased government support programs and agricultural development initiatives targeted at tribal and rain-fed farming regions, the productivity of the Bastar Plateau and Northern Hills zones has improved modestly in recent years (Kurrey *et al.*, 2023; Kumar *et al.*, 2023) ^[6]. Regional differences in cropping patterns, productivity levels, and growth trends can be highlighted by analysing paddy farming across several agroclimatic zones. A clearer picture of Chhattisgarh's changing agricultural situation can be gained by looking at the spatiotemporal shift in area, production, and productivity during the past ten years. Designing location-specific development strategies that maximise resource utilisation, boost productivity, and encourage sustainable intensification of rice agriculture in

the face of shifting climatic and socioeconomic conditions necessitates the implementation of such an approach.

Materials and Methods

The present study is based on secondary data pertaining to the area, production, and productivity of rice in Chhattisgarh, collected for a period of twelve years from 2012–13 to 2023–24. District-wise data were obtained from the Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture and Farmers' Welfare, Government of India. Additional data were sourced from the official portal of the Department of Agriculture Development, Farmers' Welfare and Biotechnology, Government of Chhattisgarh (<https://agriportal.cg.nic.in>). The dataset covers all thirty-three districts of the state, ensuring comprehensive spatial representation. The data were systematically compiled and analysed to examine trends and variations in area, production, and productivity of rice across different agroclimatic zones. To assess growth patterns over time, a linear trend model was employed.

The following regression equation was used:
Linear trend,

$$Y = a + b x$$

Where, Y= Dependent variables (Area, Production and productivity)
a = Intercept
b = Regression co-efficient
x = Period (years)

Table 1: Area, production and productivity of rice crop in Bastar Plateau zone of Chhattisgarh

District	Area	Production	Productivity
	Regression co-efficient	Regression co-efficient	Regression co-efficient
Bastar	-0.0065** (0.001)	0.0258 (0.033)	0.0327 (0.03)
Dantewada (Dakshin Bastar)	0.0031** (0.001)	0.0268* (0.04)	0.0190 (0.02)
Kondagaon	0.0152 (0.01)	0.0123* (0.02)	-0.0030 (0.05)
Sukma	0.0100 (0.01)	0.0100 (0.01)	0.0100 (0.01)

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Figures in parentheses are the standard error

Results and Discussion

From Table 1 it is revealed that the trend analysis of rice cultivation in the Chhattisgarh Plains zone reveals notable inter-district variations in area, production, and productivity over the study period. A significant positive increase in area under rice cultivation was observed in districts such as Balod (0.0118***) by 1.18 percent every year, Bazar (0.018*), and Bemetara (0.0380*), indicating a gradual expansion of cultivated land. Conversely, districts like Bilaspur (−0.0283**). For each one-year increase in bastar district, the cultivated area decreases by 0.65 percent per

year and in Dantewada increases by 0.31 percent. In terms of production, most districts recorded a positive growth trend, indicating a steady increase in rice output over the study period. The regression coefficients indicate that production in Bemetara increased by approximately 11.44 per cent per year, followed by Kabirdham with about 7.01 per cent, and Durg with around 6.20 per cent. These results indicate that while some districts experienced substantial improvements in production, others exhibited slower growth, reflecting variations in resource use, technological adoption, and production conditions across districts.

Table 2: Area, production and productivity of rice crop in Northern Hills zone of Chhattisgarh State (2012-2023)

	Area	Production	Productivity
District	Regression co-efficient	Regression co-efficient	Regression co-efficient
Balrampur	0.0183*** (0.0033)	0.0630** (0.02)	0.0445** (0.02)
Jashpur	-0.0006 (0.01)	0.0020 (0.001)	0.0024 (0.02)
Koriya	-0.0208 (0.01)	-0.0009 (0.044)	0.0205* (0.03)
Surajpur	0.0100 (0.01)	0.0260 (0.01)	0.0161 (0.01)
Surguja	-0.0026* (0.01)	0.0107* (0.01)	0.0136* (0.01)

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Figures in parentheses are the standard error

From Table 2, it is observed that the trend analysis of rice cultivation in the Northern Hills zone of Chhattisgarh indicates mixed patterns across districts. Balrampur exhibited a positive and highly significant increase in area by 1.83 per cent. The district also recorded significant increases in production and productivity, with 6.30 per cent and 4.45 per cent, respectively, both 5 per cent level of

significance indicating consistent expansion and improvement in rice cultivation. Similarly, Surguja demonstrated a significant increase in production and productivity, 1.07 per cent and 1.36 per cent, respectively. This indicates that improvements in yield have played an important role in enhancing output despite limitations in cultivated area.

Table 3: AreaTrend in area, production and productivity of rice crop in Chhattisgarh plains zone

	Area	Production	Productivity
District	Regression co-efficient	Regression co-efficient	Regression co-efficient
Balod	0.0118**	0.0981*	0.0861
Baloda bazar	0.018*	0.0981*	0.0861
Bemetara	0.0380*	0.1144**	0.1590
Bilaspur	-0.0283**	0.0350*	0.0634*
Dhamtari	-0.0012	0.0302	0.0316
Durg	0.0119*	0.0620**	0.0502*
Gariyaband	0.0079**	0.0743	0.0663
Janjgir-champa	-0.0189	-0.0283	-0.0218
Kabirdham	0.0407	0.0701*	0.0475
Kanker	0.0056*	0.0071**	-0.0006
Mahasamund	0.0091**	0.0157*	0.0135
Raigarh	-0.0164	0.0394	0.0982
Raipur	-0.0063	0.0665*	0.1737**
Rajnandgaon	-0.0031	0.0440*	0.0665
Mungeli	0.0227	0.0406	0.0379

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ Figures in parentheses are the standard error

From Table 3 The linear trend analysis of rice cultivation in the Chhattisgarh Plains zone reveals considerable inter-district variation in area, production, and productivity over the study period. The area under rice increased by about 1.18 per cent each year in Balod, 1.80 per cent in Baloda Bazar, 3.80 per cent in Bemetara, 1.19 per cent in Durg, among these, the increase in Balod was highly significant at the 1 per cent level, while Gariaband and Mahasamund were significant at the 5 per cent level. In contrast, Bilaspur showed a decline of about 2.83 per cent each year, significant at the 5 per cent level, indicating a reduction in area under rice cultivation. With respect to production, a majority of districts demonstrated a positive trend. Production increased by about 9.81 per cent each year in Balod and Baloda Bazar, 11.44 per cent in Bemetara, 6.20 per cent in Durg, 7.01 per cent in Kabirdham, 0.71 per cent in Kanker, 1.57 per cent in Mahasamund, 6.65 per cent in Raipur, and 4.40 per cent in Rajnandgaon. In terms of productivity, relatively fewer districts showed statistically significant improvements. Productivity increased by about

6.34 per cent each year in Bilaspur, 5.02 per cent in Durg, and 17.37 per cent in Raipur. Overall, the results indicate that while production growth in the Chhattisgarh Plains zone is largely driven by both area expansion and yield improvements in select districts, the uneven pattern of productivity growth highlights the need for region-specific technological and management interventions to ensure balanced agricultural development.

Conclusion

The present study analysed the spatiotemporal trends in area, production, and productivity of rice across agroclimatic zones of Chhattisgarh from 2012–13 to 2023–24, revealing significant regional disparities. In the Chhattisgarh Plains zone, production growth was largely supported by both expansion in cultivated area and improvements in productivity in selected districts, although the pattern was uneven. In contrast, the Northern Hills zone exhibited limited or declining trends in area, while moderate gains in production were primarily driven by improvements

in productivity in certain districts, indicating the role of technological and management interventions under constrained conditions. The uneven growth in productivity across districts highlighted the need for targeted, location-specific strategies focusing on enhancing yield through efficient input use, climate-resilient practices, and strengthened extension services. Such interventions were essential for achieving balanced and sustainable rice production and ensuring long-term food security in Chhattisgarh.

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