

Impact of climate change on food grain production in Jharkhand (India): An empirical assessment

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Abstract. Jharkhand, India, has experienced significant inter-annual variability in annual food grain production and yield, reflecting the impact of both climatic factors and agricultural practices. As the state's agricultural system is predominantly rainfed, variations in climatic conditions, particularly rainfall and temperature, have a direct impact on crop production and productivity.

The present study aims to examine trends in food grain production and key climatic variables and to analyse the relationship between climate change and agricultural performance in Jharkhand state of India. The study is based on secondary data collected over a specified period and employs descriptive statistical tools, including graphical analysis, to examine trends in the variables and linear regression to assess the impact of climatic variables on food grain production and yield. The findings reveal fluctuating trends in both food grain yield and production. Jharkhand also exhibited irregular rainfall patterns and a gradually increasing temperature trend over the study period. Collectively, the findings indicate that rainfall is the most important climatic variable affecting state's agricultural productivity. Rainfall has a significant positive impact, especially on yields, while temperature fluctuations seem to have minimal or no impact during the research period.

Keywords: climate change, temperature, rainfall, food grains, yield.

INTRODUCTION

Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily

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due to the burning of fossil fuels like coal, oil and gas (Infante-Amate et al., 2025; Wolf et al., 2025). Climate change is widely recognized as having significant economic implications, particularly in agriculture. Unpredictable changes in temperature and irregular rainfall patterns can severely impact crop yields and productivity. According to the Intergovernmental Panel on Climate Change (IPCC) 2007 report, even a modest increase of 1–2 °C in temperature can lead to reduced cereal production in tropical regions, including India (Bernstein et al., 2007). Agriculture is one of the most climate-sensitive sectors, particularly in developing countries like India, where a large portion of the population relies on farming for livelihood. In states such as Jharkhand, agriculture is predominantly rainfed, making it highly vulnerable to fluctuations in rainfall, temperature, and other climatic variables. Climate change, characterized by rising temperatures, altered rainfall patterns, and increased frequency of extreme weather events, poses a significant challenge to food security and agricultural productivity (Gadgil, 1995; Kumar, Parikh, 2001). Even small changes in temperature and rainfall can lead to substantial variations in crop yields, particularly for staple crops such as rice, wheat, and maize.

Studies indicate that the impact of climate change on agriculture can be both positive and negative depending on the crop type, management practices, and regional conditions (Mall et al., 2007; Naikwade, 2017). The dependence of Indian agriculture on monsoon rainfall further amplifies vulnerability, as fluctuations in precipitation directly affect crop production and productivity. Additionally, agriculture contributes to greenhouse gas emissions through practices such as rice cultivation and animal husbandry, creating a feedback loop that may exacerbate climate risks (Ahmad et al., 2011; Kumar et al., 2014).

The agricultural sector plays a crucial role in the economy of Jharkhand, contributing to food security and economic development. A significant proportion of the state's population relies on agriculture for their livelihood. The total agricultural area is approximately 1.8 million hectares, of which only about 9.3 percent is irrigated, indicating a strong dependence on monsoon rainfall (Indian Council of Agricultural Research, 2026). The primary mode of cultivation is divided between the Kharif and Rabi seasons. Rice dominates the cropping pattern, accounting for the largest proportion of the gross cropped area, followed by crops such as wheat, maize, and pulses. The state has emerged as a leading producer of pulses, surpassing national and global averages, and millet cultivation is also gaining prominence. Despite its importance, agricultural productivity remains relatively low and highly sensitive to climatic variability. The combined effects of changing rainfall patterns, rising temperatures, and limited irrigation infrastructure pose serious challenges to agricultural performance in the state. The present study aims to analyse trends in rainfall, temperature, and food grain production and yield, and to assess the impact of climatic variables on agricultural performance in Jharkhand.

MATERIALS AND METHODS

Study area

This study primarily focuses on the Jharkhand state of India, situated in eastern India between 21°58'N and 25°18'N latitude and 83°22'E and 87°57'E longitude. The state experiences a tropical monsoon climate, characterized by distinct summer, monsoon, and winter seasons (Koley, Jeganathan, 2023). Agriculture constitutes one of the primary sources of livelihood in Jharkhand. The state's agricultural system is predominantly rain-fed (Petare et al., 2016); consequently, it is highly vulnerable to climate-related changes, such as fluctuations in rainfall and temperature. The major food grain crops cultivated in the state include rice, maize, wheat, and pulses. Agricultural production

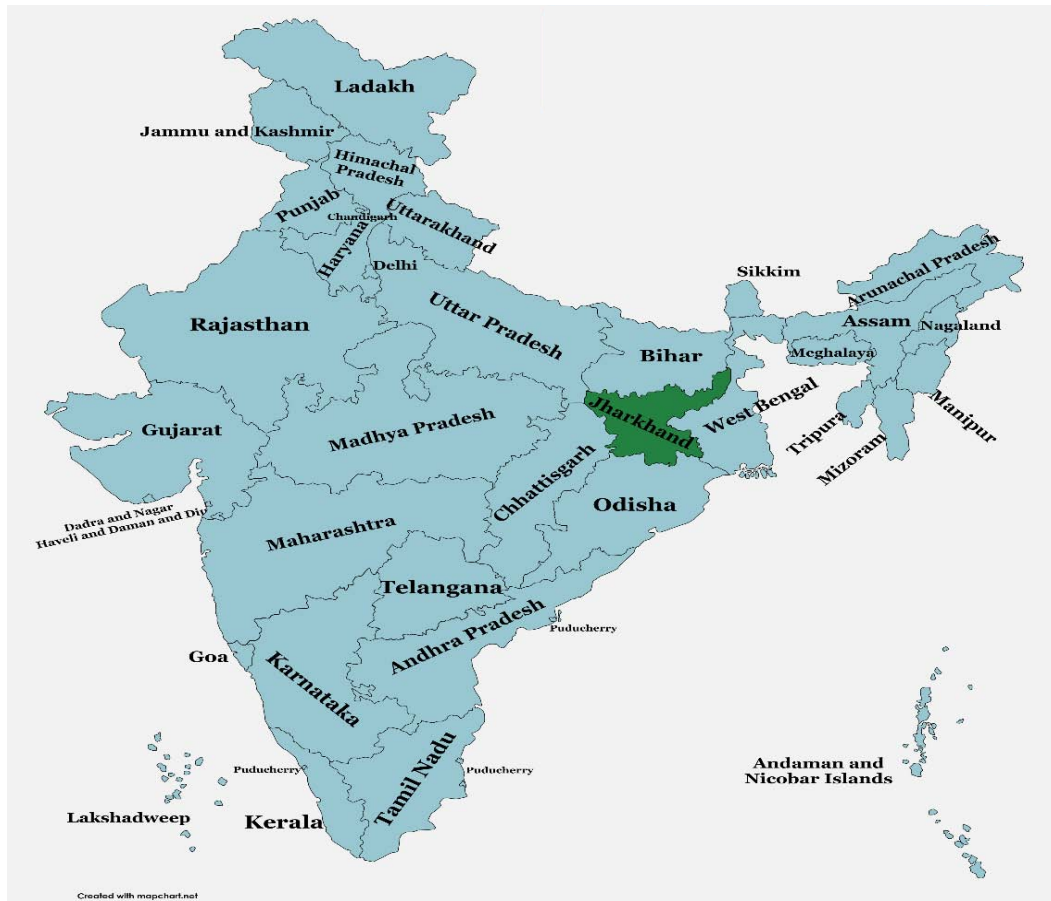


Figure 1. Geographical Location of Jharkhand in India.

Source: Prepared by the Author using MapChart.net

in Jharkhand relies primarily on the Kharif and Rabi cropping seasons, with the largest share of food grain production derived from Kharif crops (Petare et al., 2016). Figure 1 illustrates the geographical location of Jharkhand within India.

Sources of data

The study is based entirely on secondary data collected from reliable government and institutional sources. Data on the area, production, and yield of food grains were obtained from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India, through the official DES database. The food grain figures represent the aggregate values reported under the food grain category in the official DES database. The foodgrain category includes major foodgrain crops such as rice, wheat, maize, jowar, bajra, other coarse cereals, and pulses. For production, the study uses the DES-reported "Total Foodgrains" measure, which represents the aggregate physical production of foodgrain crops and is reported in tonnes or million tonnes.

Climate-related data, including annual rainfall and average temperature, were collected from the Climate Change Knowledge Portal (CCKP) of the World Bank Group. The annual climate variables were matched with the corresponding year-wise data on foodgrain production and yield to examine the relationship between climatic conditions and agricultural outcomes. Annual average mean surface air temperature was used as the temperature indicator to represent the overall thermal conditions prevailing during each agricultural year. Although the CCKP provides monthly, seasonal, minimum, and maximum

temperature data, the annual average measure was selected to maintain consistency with the annual foodgrain production and yield data and to assess the overall impact of temperature and rainfall on agricultural performance. Additional supporting information was obtained from the Jharkhand Economic Survey and other official publications.

The study period covers the agricultural years from 2002–03 to 2022–23. The year-wise agricultural data on foodgrain production and yield are reported in the source as agricultural years (e.g., 2002–03, 2003–04, and so on), and the same year notation has been retained throughout the study. Although certain climate-related data were available up to year 2024, the regression analysis was restricted to the period 2002–03 to 2022–23 due to the non-availability of consistent agricultural and climatic data for all variables for subsequent years. The study period notation has been standardized throughout the study in the format 2002–03, 2003–04, and so on. The climate variables were matched with the corresponding year-wise agricultural observations as reported in the respective data sources.

Variables used in the study

The study examines the relationship between climatic variables and agricultural performance using the variables described in Table 1.

Food grain production includes major cereals and pulses cultivated in Jharkhand. Yield was calculated as the ratio of total food grain production to total cultivated area and expressed in tonnes per hectare.

Table 1. Variables used in the study.

Variable	Unit	Nature
Food grain production	Lakh tonnes [#]	Dependent Variable
Yield	Tonnes per hectare [t/ha]	Dependent Variable
Rainfall	Millimetres [mm]	Independent Variable
Average temperature	Degree Celsius [°C]	Independent Variable

[#] 1 lakh tonne = 100000 t

Statistical tools and techniques

The collected data were compiled, tabulated, and analysed using Microsoft Excel and STATA software. Descriptive statistical techniques were used to analyse trends in rainfall, temperature, food grain production, and yield over the study period. To quantitatively assess the impact of climatic factors on agriculture, multiple regression analysis was employed. Separate regression models were estimated for food grain production and yield, with rainfall and temperature considered as the key explanatory variables.

Model Specification

The following regression model was used to examine the relationship between climatic factors and agricultural performance:

$$Y = \beta_0 + \beta_1 RF + \beta_2 TEMP + \mu$$

Where:

Y – Food grain production or yield

β_0 – Constant term or Intercept

RF – Annual rainfall (mm)

TEMP – Average annual temperature (°C)

β_1 and β_2 – Regression coefficients

μ – Error term

A parsimonious model was adopted because the analysis is based on 21 annual observations and focuses on the relationship between the two principal climatic variables (rainfall and temperature) and foodgrain production and yield. Regression-based approaches using temperature and rainfall as key explanatory variables are widely used in empirical studies examining climate-related variation in agricultural outcomes (Ray et al., 2015; Shi et al., 2013). The regression analysis was performed to evaluate the extent to which variations in rainfall and temperature influence food grain production and agricultural yield in Jharkhand.

Rainfall and temperature were included simultaneously in the model to account for their respective associations with agricultural performance while holding the other climatic variable constant. The potential for multicollinearity between the two climatic variables was assessed using the Variance Inflation Factor (VIF). The VIF for both rainfall and temperature was 1.65, with a mean VIF of 1.65, indicating that multicollinearity was not problematic in the estimated model. However, the model does not explicitly include an interaction term between rainfall and temperature or nonlinear climate effects. Given the limited number of annual observations, a parsimonious model was retained to avoid over-parameterization. Accordingly, the estimated coefficients should be interpreted as conditional associations rather than as fully isolated causal effects, and the possibility of interaction and nonlinear effects remains a limitation of the analysis.

Table 2. Food grain production (in lakh tonnes)[#] and crop yield (tonnes/ha) in Jharkhand.

Year	Food grain production (in Lakh tonnes)	Yield [t/ha]
2002–03	12.89	1.04
2003–04	22.68	0.98
2004–05	12.84	0.95
2005–06	7.95	0.62
2006–07	17.68	1.22
2007–08	17.02	1.22
2008–09	17.19	1.23
2009–10	7.77	0.67
2010–11	0.88	1.04
2011–12	16.10	1.39
2012–13	17.66	1.32
2013–14	18.62	1.37
2014–15	18.55	1.46
2015–16	11.01	0.74
2016–17	34.67	2.01
2017–18	53.08	1.74
2018–19	43.38	1.63
2019–20	53.17	2.06
2020–21	72.10	2.30
2021–22	73.68	2.38
2022–23	60.95	2.02

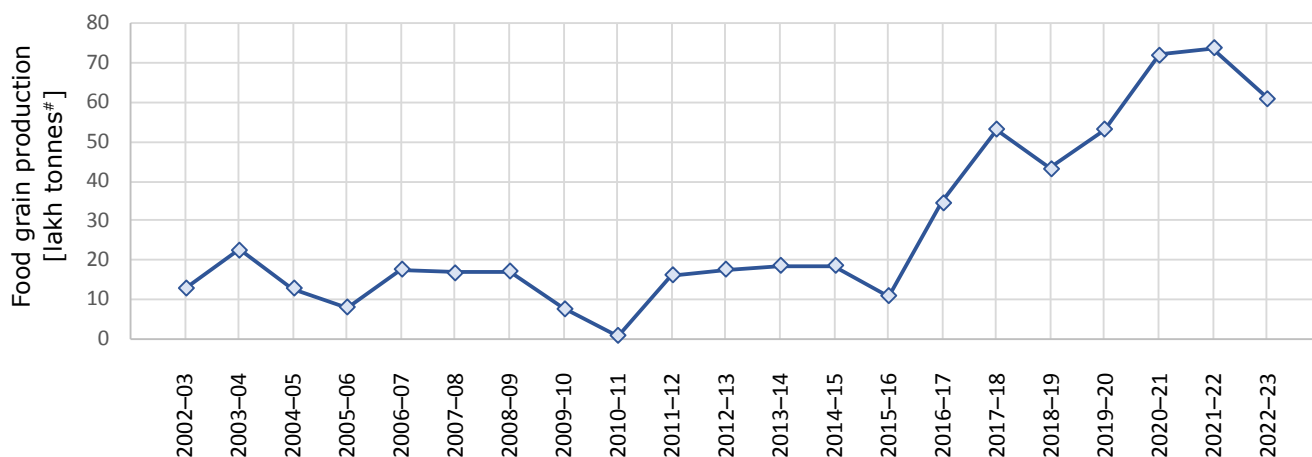
Source: Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India.

[#] 1 lakh tonne = 100000 t

RESULTS AND DISCUSSION

Trends in food grain production in Jharkhand

Jharkhand has experienced significant inter-annual variability in annual food grain production and yield from 2002–03 to 2022–23, reflecting the impact of both climatic factors and agricultural practices. Food grain production and crop yield for this period are presented in Table 2. The food grain production data collected from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India, comprise major cereals and pulses cultivated in Jharkhand, including rice, wheat, maize, and pulses. Throughout the study period, there were fluctuating trends in both food grain yield and production. Food grain yields varied from 0.62 tonnes/hectare in 2005–06 to 2.38 tonnes/hectare in 2021–22, while food grain production oscillated between 0.88 lakh tonnes in 2010–11 to 73.68 lakh tonnes in 2021–22. Despite an overall upward trend in production and yields over the last ten years, some years, such as 2005–06 and 2010–11 experienced exceptionally low production despite comparatively mod-



1 lakh tonne = 100000 t

Figure 2. Food grain production (in lakh tonnes) in Jharkhand.

Source: Directorate of Economics and Statistics, 2025, Ministry of Agriculture and Farmers Welfare, Government of India.

erate yields, indicating that adverse weather conditions and total cultivated area also played an essential role. Overall, these patterns show that Jharkhand's food grain productivity is affected by a variety of factors, including as temperature variations, rainfall unpredictability, and advancements in agricultural management techniques, and along with yield.

The Figure 2 shows the trend in food grain production (in lakh tonnes) in the state of Jharkhand from 2002-03 to 2022-23. The graph clearly shows that food grain production has experienced significant fluctuations during this period. Production levels remained relatively low in the initial years (2002-03 to 2010-11), reaching a minimum in 2010-11. Thereafter, a gradual improvement in production began in 2011-12, which was reflected in a rapid increase from 2016-17 onwards. Production reached its highest level in 2020-21 and 2021-22, exceeding 7 million tonnes. Food grain production in Jharkhand has followed a positive long-term trend over the past two decades, with occasional declines due to climate instability, rainfall variability, and changes in agricultural management practices. This trend clearly indicates that the agriculture sector in the state is vulnerable to climate change, but at the same time, technological advancements and adaptation measures have made long-term improvements in productivity possible.

Trends in climatic variables in Jharkhand

To understand the impact of climatic variability on food grain production in Jharkhand, trends in climatic variables, annual rainfall and average temperature, were first analyzed during the period 2002 to 2024. Climate change has a direct impact on the agricultural sector, especially in states where rainfed agriculture is predominant. Agriculture in Jharkhand state depends primarily on monsoon rainfall, so changes in rainfall and temperature can affect the state's food grain production as well as productivity. Table 3 presents the annual state-level average rainfall and average temperature in Jharkhand during the period 2002-2024.

The average temperature and yearly rainfall in Jharkhand have varied significantly between 2002 and 2024. Rainfall has varied from 980 mm in 2010 to 1430 mm in 2011.

Table 3. State-level average annual rainfall and temperature in Jharkhand (2002–2024).

Year	Average rainfall [mm]	Average temperature [°C]
2002	1103	25.4
2003	1094	25.4
2004	1165	25.2
2005	1063	25.3
2006	1306	25.4
2007	1357	25.4
2008	1321	25.0
2009	1014	25.9
2010	980	25.9
2011	1430	25.1
2012	1280	25.0
2013	1325	24.7
2014	1237	24.9
2015	1216	25.0
2016	1384	25.4
2017	1264	25.2
2018	1185	24.8
2019	1323	25.0
2020	1393	24.7
2021	1387	25.0
2022	1185	25.2
2023	1244	25.2
2024	1312	25.4

Source: Climate Change Knowledge Portal (World Bank Group). Retrieved from Climate Change Knowledge Portal.

Note: Rainfall and temperature values represent state-level annual averages for Jharkhand.

This suggests that there is significant inter-annual variation in rainfall during this time. Figure 3 illustrates the annual variation in average rainfall in Jharkhand over the study period. A decrease in agricultural output may have been linked to below-average rainfall in some years, including 2009, 2010, and 2015. Rainfall remained relatively stable from 2002 to 2005, but a significant increase was observed between 2006 and 2008. This was followed by a sudden decline in rainfall in 2009 and 2010, reaching its lowest level (approximately 1000 mm) in 2010. A sharp increase in rainfall was observed in 2011, reaching approximately 1430 mm, the wettest year of the entire study period. Rainfall subsequently declined again, but relatively better rainfall was recorded in 2016, 2020, and 2021. In recent years (2022–2024), a slight decline in rainfall followed by a partial recovery can be observed. Rainfall patterns in Jharkhand have been irregular and unstable during the period 2002 to 2024. This situation points to the fact that the state's agriculture is highly dependent on climatic conditions, and such fluctuations in rainfall can have a direct impact on food grain production and crop productivity.

Figure 4 illustrates the annual average temperature in Jharkhand over the study period. The average temperature trend appears relatively stable, exhibiting limited fluctuations between 24.7 °C in year 2013 and 25.9 °C

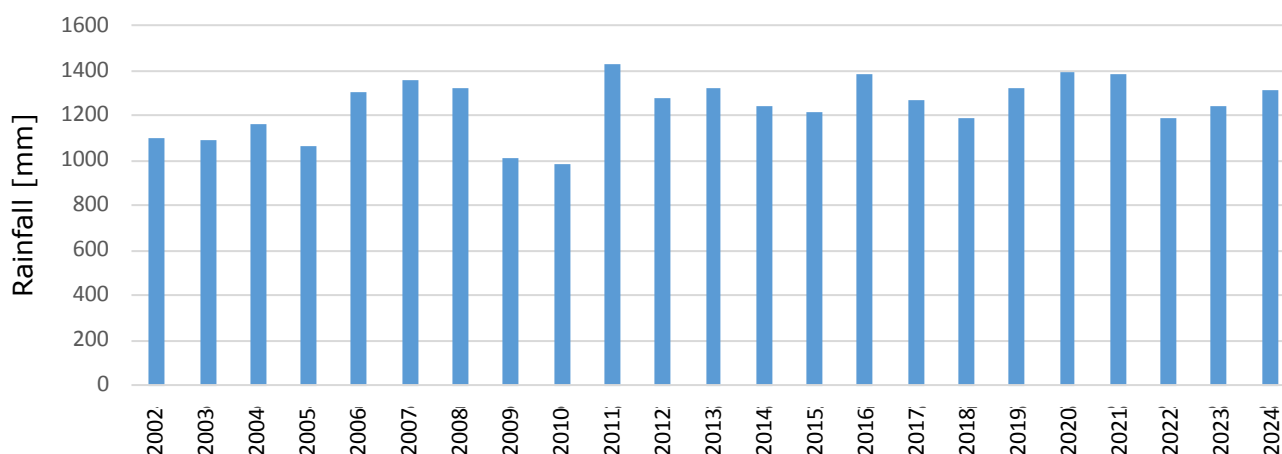


Figure 3. Annual average rainfall (in mm) for Jharkhand.

Source: Climate Change Knowledge Portal, 2025. World Bank Group, Retrieved from <https://climateknowledgeportal.worldbank.org/>

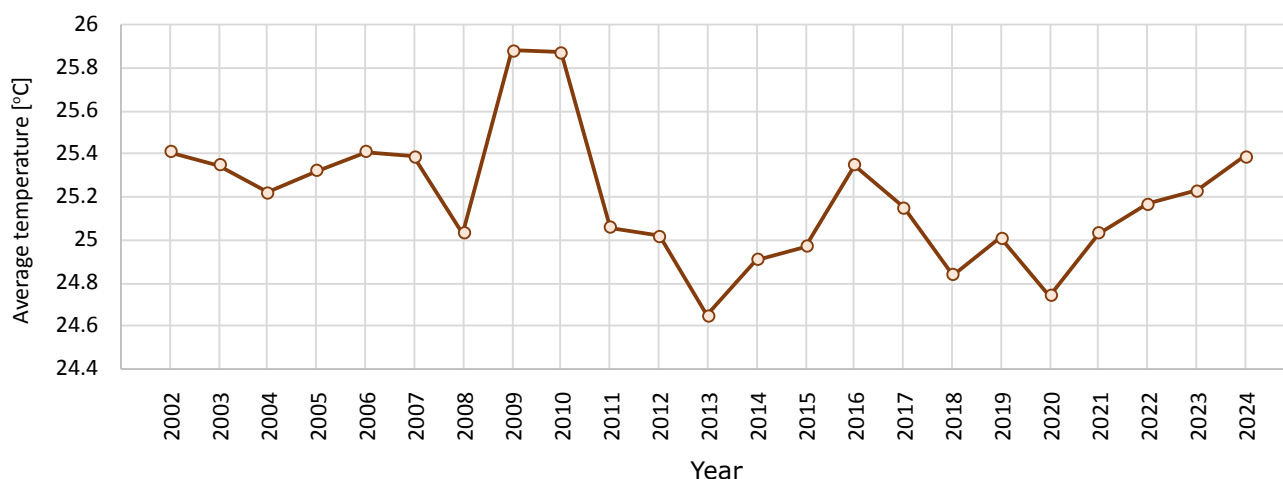


Figure 4. Annual average temperature (in °C) for Jharkhand.

Source: Climate Change Knowledge Portal, 2025. World Bank Group, Retrieved from <https://climateknowledgeportal.worldbank.org/>

in year 2009. Although this temperature difference appears minor, for an agro-ecological system, even this level of increase can impact crop productivity, moisture retention, and evaporation rates. Jharkhand's average temperature experiences cyclical fluctuations of slight increases and decreases, which are indicators of climate change in the state. From 2002 to 2008, the average temperature remained stable between 25 °C and 25.4 °C, while a significant increase was recorded in 2009 and 2010, reaching over 25.8 °C, indicating extreme heat and aridity in Jharkhand. Temperatures then declined between 2011 and 2013, reaching a low of around 24.7 °C. Temperatures again increased in 2016, and thereafter, slight fluctuations in temperature persisted between 2017 and 2021. A gradual increase in average temperatures has been observed in recent years (2022–2024), indicating that a gradual warming trend is developing in the state.

Jharkhand's agricultural system is primarily rainfed, making it sensitive to climatic variations. Higher temperatures may contribute to faster depletion of soil moisture and increased crop evapotranspiration, which can lead to water stress for crops, particularly water-intensive crops like rice. Long and intense heat periods affect flowering and grain filling, leading to a decline in yield. Thus, Figure 4 indicates that rising average temperatures and extreme heat spells in Jharkhand could pose a serious challenge to agricultural productivity in the future, especially if combined with irregular rainfall.

Overall, Jharkhand has exhibited a trend of irregular rainfall patterns and gradually increasing temperatures over the period 2002 to 2024. This situation points to the impacts of climate change in the state, which could pose a challenge to the sustainability of the agricultural sector. The combined effect of low or delayed rainfall and high temperature conditions adversely influences crop yields, soil moisture, and sowing patterns, resulting in yield fluctuation and regional disparities in agricultural productivity. Consequently, crop yield fluctuation and regional disparities in agricultural productivity emerge in the state. Therefore, this study analyzes these climatic variables by linking them with agricultural productivity.

Empirical analysis of climatic variables and agricultural performance

To quantitatively assess the relationship between climate changes and agricultural performance, an empirical regression analysis was conducted using annual data on

rainfall, average temperature, food grain production, and yield from 2002 to 2022 in Jharkhand. The time period is restricted due to the non-availability of consistent data for all variables beyond 2022. This section presents and interprets the statistical results obtained from the analysis. The objective is to identify how fluctuations in key climate indicators have affected agricultural productivity over time. By examining the direction, magnitude, and significance of the regression coefficients, this analysis provides evidence of the extent to which rainfall and temperature contribute to variations in food grain production and crop yield in the state.

Table 4 shows the descriptive statistics of the climatic and agricultural variables used in the analysis. During the period 2002–2022, average annual rainfall was approximately 1,238.64 mm, with a standard deviation of 131.36 mm, indicating moderate inter-annual variability in rainfall in Jharkhand. The average temperature remained relatively stable at 25.18 °C, with very little variation (standard deviation = 0.32 °C), indicating that even though temperature changes are gradual, even small fluctuations can affect crop productivity in a sensitive agro-climatic zone like Jharkhand.

Table 4. Descriptive statistics of climate and agricultural variables in Jharkhand.

Variable	Mean	Std. dev.	Minimum	Maximum
Rainfall [mm]	1238.64	131.36	979.64	1430.05
Average temperature [°C]	25.18	0.32	24.65	25.88
Food grain production [lakh tonnes]	28.09	22.08	0.88	73.68
Yield [t/ha]	1.40	0.52	0.62	2.38

Source: Author's calculation based on data from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India, and Climate Change Knowledge Portal, World Bank Group. (Table 1 and 2)

With a mean of 28.09 lakh tonnes and a standard deviation of 22.08 lakh tonnes, foodgrain production showed substantial year-to-year variation, ranging from a minimum of 0.88 lakh tonnes in 2010–11 to a maximum of 73.68 lakh tonnes in 2021–22. The exceptionally low production recorded in 2010–11 was primarily associated with a sharp contraction in the area under foodgrain cultivation. The cultivated area declined from 1,163,849 hectares in 2009–10 to 84,850 hectares in 2010–11 (Directorate of Economics and Statistics), representing a decline of approximately 92.7 percent. In contrast, foodgrain yield increased from 0.67 tonnes/ha in 2009–10 to 1.04 tonnes/ha in 2010–11, indicating that the drastic fall in production was mainly attributable to the reduction in cultivated area rather than a comparable decline in yield. This sharp contraction coincided with the severe drought conditions reported in Jharkhand in 2010, when deficient monsoon conditions adversely affected kharif sowing and agricultural activities. Thus, the unusually low foodgrain production in 2010 appears to have been largely associated with the substantial reduction in the area brought under cultivation during the drought-affected period.

This broad range illustrates how both climatic and non-climatic factors, such as resource utilisation, irrigation availability, and monsoon behaviour, have a significant impact on agricultural production. Crop yield (tonnes/hectare) also varied significantly (SD = 0.52 tonnes/hectare), ranging from 0.62 tonnes/hectare to 2.38 tonnes/hectare, with an average of 1.40 tonnes/hectare. These variations in production and yield highlight the sensitiveness of Jharkhand's agriculture to climatic shifts, especially rainfall variations.

The relationship between the climatic variables rainfall and average temperature and two important agricultural outcomes, food grain production (in lakh tonnes) and yield (in tonnes per hectare) for the years 2002–2022 in Jharkhand, is examined using multiple linear regression models. The estimated regression coefficients, standard errors, p-values, and significance levels for rainfall and temperature in relation to food grain production and yield are shown in Table 5. Table 6 reports the overall statistical performance of the regression models, including R-squared, adjusted R-squared, F-statistic, and the corresponding probability values.

Table 5. Regression results for the impact of climatic variables on food grain production and yield in Jharkhand (2002–03 to 2022–23).

Dependent variable	Independent variable	Coefficient	Std. error	P-value	Significance
Food grain production [lakh tonnes]	Rainfall	0.052	0.043	0.248	Not Significant
	Temperature	-18.93	17.93	0.305	Not Significant
	Constant	440.55	487.09	0.378	-
Yield [t/ha]	Rainfall	0.0023	0.0009	0.022	Significant
	Temperature	-0.197	0.376	0.608	Not Significant
	Constant	3.528	10.217	0.734	-

Source: Author's calculation based on data from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India, and Climate Change Knowledge Portal, World Bank Group. (Table 1 and 2)

Table 6. Summary of regression models for foodgrain production and yield in Jharkhand (2002–03 to 2022–23).

Model	R-squared (R^2)	Adjusted R-squared	F-statistic	Prob > F
Model 1: Food grain production [lakh tonnes]	0.274	0.193	3.40	0.056
Model 2: Yield [t/ha]	0.429	0.365	6.75	0.0065

Source: Author's calculation based on data from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India, and Climate Change Knowledge Portal, World Bank Group. (Table 1 and 2)

Note: Regression analysis is restricted to the period 2002–03 to 2022–23 due to the non-availability of complete data for all variables beyond this period.

In the first model, where food grain production serves as the dependent variable, both rainfall and temperature were found to have statistically insignificant effects. The rainfall coefficient (0.052) shows a positive but insignificant relationship, indicating that while increased rainfall may contribute to increased food grain production, this effect is not strong enough to be statistically significant. In contrast, the temperature coefficient (-18.93) shows a negative relationship with food grain production, meaning that increasing temperatures may slightly reduce production levels, although this relationship also lacks statistical significance. The coefficient of determination (R^2) is 0.274 for Model 1 (food grain production) (Table 6), meaning that rainfall and temperature explain approximately 27.4 percent of the variation in food grain production. The F-statistic value of 3.40 with a probability value of 0.056 indicates that the overall model is not statistically significant at the 5 percent level of significance, although it approaches

significance, suggesting a modest explanatory power of climatic factors on food grain production.

The yield (tonnes/hectare) model exhibits a more robust relationship. Rainfall has a positive and statistically significant coefficient (0.0023; $p = 0.022$), meaning that more rainfall greatly boosts crop productivity. This result emphasises how crucial sufficient rainfall is to the state's crop yields. Temperature, however, continues to be an insignificant predictor in this model as well, with a negative coefficient (-0.197; $p = 0.608$), suggesting that yield values were not statistically significantly affected by modest temperature fluctuations over the research period. With an R^2 value of 0.429 and an adjusted R^2 value of 0.365, Model 2 (yield) shows stronger explanatory power, meaning that the independent variables account for around 43 percent of the variation in crop yield. This model is statistically significant at the 5 percent significance level, with the value of F-statistic (6.75) and its corresponding p-value (0.0065).

These findings collectively imply that the most significant climate variable influencing Jharkhand's agricultural productivity is rainfall. Rainfall has a significant positive impact, especially on yields, while temperature fluctuations seem to have minimal or no impact during the research period. This result emphasizes the state's reliance on monsoon patterns and the vulnerability of agricultural sector towards rainfall variations. Therefore, encouraging climate-resilient agricultural practices and strengthening irrigation infrastructure may be essential measures to sustain and increase productivity in spite of climate variability.

The current research analyzed the impact of climatic variables (rainfall and temperature) on the agricultural performance (food grain production and yield) in Jharkhand, India over the period of time. The results indicate that the variation in climatic variables has a substantial impact on food grain production and agricultural yield of the state.

The study used multiple regression analysis to examine the relationship between the agricultural performance indicators: foodgrain production and yield, and the climatic variables, namely rainfall and temperature. The regression results indicate that rainfall has a positive and statistically significant association with foodgrain yield in Jharkhand. The positive coefficient of rainfall suggests that, holding average temperature constant, higher rainfall is associated with higher foodgrain yield during the study period. However, the relationship between rainfall and foodgrain production was positive but statistically insignificant. Similarly, the coefficient of average temperature was negative but statistically insignificant in both the production and yield models. The results therefore suggest that rainfall played a more pronounced role in explaining variations in foodgrain yield than in overall foodgrain production during the study period. Considerable year-to-year variation in foodgrain production and yield was observed, which may reflect variations in climatic conditions as well as changes in the area under cultivation and other agricultural factors.

Agricultural productivity was comparatively lower in years with insufficient rainfall, while higher rainfall years generally experienced higher production levels. These results demonstrate that rainfed agriculture is affected by irregular monsoon patterns and unpredictable weather. Similar findings were reported by Shahnawaz and Haque (2026) in his study on climate change and agricultural productivity. The study observed a positive and statistically significant rainfall coefficient, indicating that rainfall contributes to enhancing rice productivity. However, the magnitude of this effect is small, which likely reflects the soil characteristics of Jharkhand, specifically, its low water-holding capacity. Wadood and Kumari (2009) also concluded that the quantitative increase in rainfall can be considered a positive change on agriculture for Jharkhand. Likewise, Venkatareddy and Nanjundaswamy (2018) found that rainfall variability has a long-term impact on the

performance of agricultural production in India. Rainfall improves soil moisture availability, supports crop growth, and enhances agricultural output, particularly for water-intensive crops such as rice, which is the dominant crop in Jharkhand.

The regression analysis results for temperature further revealed that average temperature has a negative relationship with food grain production and yield, although the relationship was statistically insignificant. This finding suggests that rising temperatures may adversely affect agricultural productivity in the long run. Similar findings were observed by Birthal et al. (2014), who reported that increasing temperatures adversely affect the crop yield in India. Jain (2023) also observed rising temperatures and irregular rainfall patterns in rain-fed regions are having a disproportionately negative impact on crop harvests. In Jharkhand, increasing temperatures can accelerate soil moisture loss and intensify water stress conditions, particularly in rainfed farming systems where irrigation facilities remain limited.

The results of the study also align with the findings of the Intergovernmental Panel on Climate Change (2022), which highlighted that agricultural production and food security in developing nations are seriously threatened by climate variability and changing weather patterns. Rising temperatures and irregular rainfall patterns might increase production uncertainty and negatively impact farmers' livelihoods in Jharkhand, where agriculture is primarily dependent on monsoon rainfall.

Overall, the findings of the study indicate that agriculture in Jharkhand remains highly vulnerable to climatic variability due to its dependence on rainfed farming practices. Climatic factors play a very significant role in the agricultural productivity. However, the regression results shows that climatic variables explain a small part of the variation in food grain production and yield. This implies that other non-climatic factors may also influence agricultural performance. The results emphasize the need for climate-resilient agricultural strategies, including improved irrigation infrastructure, water conservation techniques, crop diversification, and the promotion of climate-resilient farming technologies. Such measures can help reduce agricultural vulnerability, improve productivity, and strengthen food security in the state in the long run.

CONCLUSION

The findings indicate that variations in rainfall and temperature are relevant to agricultural performance in Jharkhand, particularly in its predominantly rainfed agricultural system. The present study found that rainfall has a positive and statistically significant impact on food grain yield and positive, but statistically insignificant, on food grain production, indicating that adequate rainfall plays a crucial role in enhancing agricultural productivity in the state. In contrast, average temperature exhibited a negative relationship with food grain production and yield, although the relationship was statistically insignificant. These findings suggest that agriculture in Jharkhand remains highly dependent on monsoon rainfall, and variations in rainfall levels lead to considerable fluctuations in agricultural productivity.

The regression results further indicate that climatic variables only partially explain variations in food grain production, implying that non-climatic factors may also influence agricultural performance. However, the present study specifically focused on climatic variables such as rainfall and temperature. Among the climatic factors analysed, rainfall emerged as the most influential factor affecting agricultural yield, whereas temperature showed comparatively less impact during the study period.

Based on these findings, there is a need to promote climate-sensitive and sustainable agricultural practices in Jharkhand. Strengthening irrigation infrastructure, adopt-

ing water conservation techniques, encouraging crop diversification, and promoting climate-resilient agricultural technologies can help reduce the vulnerability of agriculture to climatic variability. Such measures would contribute to improving agricultural productivity, ensuring food security, and stabilizing farmers' livelihoods in the long run.

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