**An Analysis of Trend, Growth and Instability of Major Cereals and Millets in Chhindwara District of Madhya Pradesh, India**

**ABSTRACT**

There is a significance with increasing population, the demand for the food grains has also increased. Madhya Pradesh has been one of the leading agricultural state in the country. This study is conducted to analyse the trend, growth and instability of the major cereals and millets for the span of 22 years from 1998 to 2019 in Chhindwara district of Madhya Pradesh, India since it had the largest area under Cereals and Millets cultivation. Four major cereals and millet namely Paddy, Wheat, Maize and Jowar were selected for the purpose of the study as ~~they~~ its covered more than 90 per cent area in each year.

The research methodology of study is….Explain the research design, sampling design and pilot study…

The types of data analysis and research findings is…The trend has been worked out using the graphical plot method. The growth rate has been worked out using Average Annual Growth Rate (AAGR) and Simple Growth Rate (SGR). For analysing the instability in the Gross Cropped Area, Cuddy-Della Valle Index (CDVI) was used. The total Cereals and Millets increased from 48.22 per cent in 1998 to 78.28 per cent in 2019. Maize covered the largest area with 36.78 per cent followed by Wheat (34.29 %), Jowar (12.67%) and Paddy (6.15 %). Maize had a positive growth rate of 8.38 per cent whereas Wheat had a positive growth rate of 4.97 per cent. Paddy experienced a negative growth of -2.48 per cent while Jowar had a negative growth of -7.88 per cent. Maize was found to be highly unstable with a CDVI of 30.11 per cent. Wheat and Paddy were found to be moderately unstable with a CDVI of 20.09 per cent and 16.39 per cent respectively. Jowar was comparatively stable with a CDVI of 6.49 per cent.

Theoretical and practical implications of study are Overall, the results revealed that Maize and Wheat had the largest area and highest growth rate but both of them were found to be least stable. Continuous cultivation of Wheat and Maize may detriment the fertility of land. Farmers should focus on adapting crop rotation to replenish the fertility of soil in the district.

The contributions of study are There is a need to recharge, maintain and manage the irrigation resources in the region. Storage houses should be constructed in order to reduce the wastage of Wheat and Maize.

**Keywords:** *Trend, Growth, Instability, Cereals, Millets, Chhindwara District, Food Grain Production, Smart Agricultural Policies, Sustainable Agricultural Development*

1. **INTRODUCTION**

Major cereals like rice (Oryza sativa), wheat (Triticum aestivum), and maize (Zea mays) as well as millet crops like finger millet (Eleusine coracana), pearl millet (Pennisetum glaucum), and small millets are essential to India's nutritional well-being, rural livelihoods, and national food security. Over 75% of India's food grain production comes from rice and wheat, which are also essential components of the Public Distribution System (PDS), which guarantees millions of people have access to food (Government of India, 2023). Due to their high nutritional content, especially in iron, calcium, and fiber, low input requirements, and climate resilience, millets which are traditionally farmed in arid and semi-arid regions are receiving fresh attention through programs like the International Year of Millets 2023 (ICAR-IIMR, 2023). Promoting them is particularly crucial in the fight against non-communicable diseases and hidden hunger in both urban and rural populations (Rao *et al*., 2017). Additionally, by improving soil health and biodiversity, millet production promotes sustainable agriculture, which makes it essential to India's climate-smart agricultural policies. Millets are nutritionally superior to common cereals like wheat and rice. They are abundant in protein, fiber, vitamins and essential fatty acids. They are rich in minerals like Magnesium, Calcium, Iron and Zinc. This makes them effective in preventing diseases such as hypertension, diabetes and cardiovascular diabetes (Kotapalli *et al*., 2024).

Madhya Pradesh has always been a major production hub of Cereals and Millets in India. The agricultural GDP in Madhya Pradesh increased at 7.5 per cent per annum during 2005-06 to 2018-19 (Gulati *et al*., 2021). The area under cultivation for small millets is decreasing by 5.34 per cent annually, while productivity is improving due to better farming techniques. Studying these trends helps in formulating policies to revive the decline and optimize yield (Dwivedi *et al.,* 2024). Local cereals and millets also helps in preserving traditional varieties and farming knowledge crucial for long term food security (Jain & Lal, 2017).With time, it is crucial to estimate the changes in production and productivity of the crop to keep a track on the direction of change in order to minimize the losses and stabilize the profit. Therefore, a study on Trend, Growth and Instability of major cereals and millets in Madhya Pradesh is essential to understand the increase or decrease in the production trends in the state as it can play a significant role in improving nutritional intake among people especially the vulnerable populations (Chandrakar, 2008). It holds potential for economic security if revived through better policies and farmers support (Devi *et al.,* 2024).

Table 1 reveals the share of major cereals and millet in the state of Madhya Pradesh. Cereals and millets covered 41.21 per cent area from the Gross Cropped Area (GCA) in TE 2000 which increased to 45.70 per cent in the TE 2019. The share of Paddy, Maize and Wheat had increased while the share of Jowar had decreased in the total Cereals and Millets. The share of paddy had increased from 20.81 in TE 2000 to 21.17 per cent in the TE 2019. The share of area under Maize increased from 9.85 per cent to 10.62 per cent from TE 2000 to TE 2019. Wheat shared 51.82 per cent in TE 2000 which increased to 63.29 per cent in TE 2019. The share of area under Jowar decreased drastically from 8.44 per cent in TE 2000 to 1.13 per cent in TE 2019 in the state.

Table 1: Share of Major Cereals and millet from total cereals and millets in Madhya Pradesh

|  |  |  |  |
| --- | --- | --- | --- |
| **Type/Shares** | **TE 2000** | **TE 2010** | **TE 2019** |
| Paddy | 20.81 | 20.91 | 21.17 |
| Jowar | 8.44 | 5.69 | 1.13 |
| Maize | 9.85 | 10.41 | 10.62 |
| Wheat | 51.82 | 55.93 | 63.29 |
| Overall Share of Paddy, Wheat, Jowar and Maize | 90.92 | 92.94 | 96.21 |
| Cereals and Millets (from GCA) | 41.21 | 36.69 | 45.70 |

Note: TE? GCA? (Units in %)

*Source: Directorate of Economics and Statistics, (2025)*

**2.0. THE OBJECTIVE OF STUDY- explain**

**2.1. The General Objective of Study**

This study is conducted to analyse the trend, growth and instability of the major cereals and millets in Chhindwara district of Madhya Pradesh, India

**2.2. The Specific Objectives of study**

The research was conducted to achieve the following objectives:

1. To study the trend of Gross Cropped Area under the major cereals and millets in Chhindwara district of Madhya Pradesh.
2. To determine the trend of share of area under major cereals and millets in the Chhindwara district.
3. To evaluate the growth in the Gross Cropped Area under major cereals and millets.
4. To analyze the instability in Gross Cropped Area under the major cereals and millets.

**2.3. The Literature Review of study**

**3.0. RESEARCH METHODS**

**3.1. Research Design… elaborate**

**3.2. Sampling Design…elaborate**

**3.3. Study Period:** The study had been conducted for the period of 22 years from 1998 to 2019.

**3.4. Selection of Study Area:** Chhindwara district of Madhya Pradesh has been selected for the purpose of the study because it had the largest area (76,09270 ha) under cereals and millets in the state during the study period.

**3.5.Selection of Data:** The research was purely based on secondary data which was obtained from the official website of Ministry of Agriculture and Farmers welfare, Land use statistics information system, Government of India (aps.dac.gov.in).

**3.6. Selection of Crops:** The data of Gross cropped area under major cereals and millets namely Paddy, Maize, Wheat and Jowar had been taken in the district because these four crops covered at least 40 per cent area from the Gross cropped area and more than 80 per cent area from the total cereals and millets in each year throughout the study period.

**3.7.Analytical Tools and methods:**

* + 1. **Trend analysis:** A Trend line is the geometrical representation of direction of change in a time series data. A Trend line typically takes the form of a linear equation called as *‘Trend equation’* and represents the relationship between two variables in a dataset. Usually, it consists of slope and an independent variable. For the purpose of the research, the trend of Gross Cropped Area under the selected crops has been analyzed. The trend of the share of selected crops among the total cereals and millets has also been analyzed for the study period using the following trend equation,

**Y =a + bT**

Where,

Y = Dependent Variable (Gross Cropped Area, Share of Major Cereals and Millets)

a = Constant (Intercept of trend line). Value when T=0.

b = Rate of change (Slope of trend line)

T = Time (Years)

**3.7.2.** **Simple Growth Rate:** The formula represents the growth rate from the linear trend curves. For area under crops, these are normally found appropriate (Sananse & Maidapwad, 2009).

Where,

b : Regression Coefficient

: Mean of Dependent Variable (Gross Cropped Area, Share of Major Cereals and Millets)

**3.7.3. Average Annual Growth Rate (AAGR)** The AAGR represents the average yearly increase or decrease in variable over a specific period of time. AAGR allows for an easy comparison of trends across different crops and regions (Pérez Andrade & Romero-Padilla, 2022). This method of calculation of growth rate is robust to outliers in the data and provides consistent results (Chaturvedi *et al.,* 2024).

**AAGR =**

Where,

denotes the area in the succeeding year

denotes the area in the current year

‘ln’ denotes natural log to the base 10

T denotes total number of years within particular period

**3.7.4. Cuddy-Della Valle Instability Index (CDVI)**: The CDVI is a statistical measure used to assess the instability in time series data, particularly in agricultural contexts. Developed by Cuddy and Della Valle in 1978, the Index is particularly useful for data that exhibit trends, as it adjusts for these trends to provide a clearer picture of variability.

Cuddy-Della Valle usedthis index to compute the instability in the production. (Krishan and Chanchal, 2014), (Deb and Pramanik, 2015), (Vekariya *et al*., 2020), (Mishra *et al.*, 2023) also used Cuddy Della Valle Index in their studies to analyse the instability and considered the coefficient of determination from a time-trend regression adjusted by the number of degrees of freedom. This Index corrects the coefficient of variation in long term trend. It shows the exact direction of instability. Therefore, it is a better measure to capture instability in agricultural production (Vilhekar *et al.,* 2022).The instability in the growth of area under the major cereals and millets was analyzed using CDVI.

**CDVI =**

Where,

σ : Standard Deviation

: Arithmetic Mean of Gross cropped area of different crops in the study period

: Adjusted coefficient of Determination

The index categorizes instability into three levels:

Low Instability: 0% to 15%

Medium Instability: 15% to 30%

High Instability: Above 30%

**4.0. RESULTS & DISCUSSION**

**4.1. Trend of Gross Cropped Area of major cereals and millets in Chhindwara District**

Table 2 show the year wise data of Gross Cropped area from 1998 to 2019 for the four major crops: Paddy, Wheat, Maize and Jowar. Based on the table, it can be observed that Paddy had decreased from 20,119 hectares to 13,645 hectares whereas Wheat experienced an increasing trend when its area increased from 101,851 ha in 1998 to 256,307 hectares in 2019. The area under Maize had a strongly increasing trend since its area increased from 55,428 hectares to 345,534 hectares. A significant reduction in the area under Jowar cultivation was observed, dropping from 63,321 hectares to 7,241 hectares by 2019. A similar finding from the study conducted by Singh *et al*., (2017), estimated the trend and growth of area in Madhya Pradesh and India from 2001 to 2015 and found that the area under small millets decreased by 57.06 %. It showed a highly significant decline with a magnitude of -21.48 thousand ha per year and decrease in the Annual Compound Growth Rate by 7.05 %. Similar trend was observed for India with a decrease in area by -48.52 % with a decline of -53.18 % per year and deceleration of Annual Compound Growth Rate of -5.41 % per year. (which table need to refer on this..)

Table 2: The Gross Cropped Area under major cereals and millets in Chhindwara District From 1998 - 2019

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **Paddy\*** | **Wheat\*** | **Maize\*** | **Jowar\*** |
| **1998** | 20,119 | 101,851 | 55,428 | 63,321 |
| **1999** | 25,405 | 104,202 | 84,298 | 66,069 |
| **2000** | 24,750 | 61,486 | 70,082 | 64,821 |
| **2001** | 25,426 | 59,831 | 80,696 | 62,288 |
| **2002** | 25,431 | 71,348 | 73,579 | 61,062 |
| **2003** | 24,282 | 84,177 | 81,991 | 57,573 |
| **2004** | 22,682 | 84,257 | 76,013 | 53,088 |
| **2005** | 21,568 | 91,935 | 74,553 | 49,095 |
| **2006** | 20,557 | 105,946 | 85,132 | 43,898 |
| **2007** | 20,459 | 110,732 | 92,126 | 39,523 |
| **2008** | 19,254 | 82,751 | 87,069 | 38,892 |
| **2009** | 18,751 | 111,114 | 88,881 | 38,475 |
| **2010** | 18,316 | 114,454 | 94,379 | 36,610 |
| **2011** | 18,142 | 126,936 | 124,799 | 27,388 |
| **2012** | 13,938 | 138,574 | 134,979 | 29,915 |
| **2013** | 13,808 | 146,144 | 154,251 | 22,170 |
| **2014** | 17,046 | 152,228 | 180,061 | 19,209 |
| **2015** | 7,996 | 152,230 | 197,877 | 19,011 |
| **2016** | 19,021 | 147,577 | 247,915 | 16,578 |
| **2017** | 21,392 | 179,744 | 278,104 | 12,373 |
| **2018** | 19,467 | 168,165 | 301,784 | 9,049 |
| **2019** | 13,645 | 256,307 | 345,534 | 7,241 |
| **Total** | **431,455** | **2,651,989** | **3,009,531** | **837,649** |

Note: \*-Unit in Hectares

Source:

Figure 1 below indicates the decrease in Gross Cropped Area of Paddy from 20,119 ha in 1998 to 13,645 ha in 2019. The area under paddy took a sudden drop in 2015 with an area of 7,996 ha, thereafter increased sharply in the next year. It took a major peak in the year 2017 with an area of 21,392 ha. Overall, the paddy was found to follow a decreasing trend in Chhindwara district with a b-value of -485.87 during the study period. Figure 2 signifies that the area under Jowar kept on decreasing throughout the study period. It decreased from 63,321 ha in 1998 to 7,241 ha in 2019. It increased slightly in the year 2012, with the area covered found to be 29915 ha. Overall, the area under Jowar was found to follow a decreasing trend with a b-value of -2999. Although the area under Paddy and Wheat decreased in the district, the area under maize increased from 55,428 ha in 1998 to 345,534 ha in 2019. Overall, the area under Maize followed an increasing trend with a b-value of 11,461 during the study period in the district (Figure 3). The area under Wheat increased from 101,851 ha in 1998 to 256,307 ha in 2019. The area decreased suddenly from 104,202 ha in 1999 to 61,486 ha in 2000. The area was found to increase suddenly from 168,165 ha in 2018 to 256,307 ha in 2019. Overall, the area under Wheat followed an increasing trend with a b-value of 5,992.9 during the study period in Chhindwara (Figure 4).

Figure 1: Gross cropped area of Paddy from 1998-2019

Source:

Figure 2: Gross cropped area of Jowar from 1998-2019

Source:

Figure 3: Gross cropped area of Maize from 1998-2019

Source:

Figure 4: Gross cropped area of Wheat crop from 1998-2019

Source:

**4.2. Trend of share of area under major cereals and millets in the Chhindwara district of Madhya Pradesh**

Table 3 reveals the share of area under Cereals and Millets had increased from 48.22 per cent in 1998 to 78.28 per cent in 2019. In the last six years during our study period, the contribution of cereals and millets had increased to more than 50 per cent which further increased to more than 70 per cent in the last two years. On an average, the cereals and millets contributed 52.63 per cent to the Gross Cropped Area during the study period of 22 years. Figure 5 and Table 4 depicts that the share of area under Paddy and Jowar decreased whereas the share of area under Wheat and Maize increased from the total Cereals and Millets in Chhindwara. The contribution of Paddy to the total cereals and millets was 6.78 per cent in 1998 which decreased to only 2.17 per cent in 2019. The share of Wheat increased from 34.31 per cent in 1998 to 40.70 per cent in 2019. The area under maize increased from 18.67 per cent to 54.87 per cent covering more than half of the share among total cereals and millets in 2019. The share of area under Jowar decreased drastically from 21.33 per cent to only 1.15 per cent in 2019. On an average, during the study period, Maize had the highest share of 36.78 per cent followed by Wheat (34.29 %), Jowar (12.67 %) and Paddy (6.15 %) in the total cereals and millets in the Chhindwara district.

Table 3: The Share (%) of Cereals and Millets in the Gross Cropped area in Chhindwara district from 1998-2019

|  |  |
| --- | --- |
| **Year** | **Share of Cereals and Millets (%)** |
| **1998** | 48.22 |
| **1999** | 54.14 |
| **2000** | 50.44 |
| **2001** | 50.85 |
| **2002** | 49.14 |
| **2003** | 49.05 |
| **2004** | 45.70 |
| **2005** | 46.00 |
| **2006** | 45.88 |
| **2007** | 47.03 |
| **2008** | 44.69 |
| **2009** | 45.63 |
| **2010** | 44.04 |
| **2011** | 47.74 |
| **2012** | 48.05 |
| **2013** | 49.95 |
| **2014** | 53.42 |
| **2015** | 55.16 |
| **2016** | 62.74 |
| **2017** | 69.24 |
| **2018** | 72.48 |
| **2019** | 78.28 |
| **Average** | 52.63 |

Source:

Table 4: The Share (%) of GCA under Paddy, Wheat, Maize and Jowar in the total Cereal and Millets in Chhindwara district from 1998-2019

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **Paddy** | **Wheat** | **Maize** | **Jowar** |
| **1998** | 6.78 | 34.31 | 18.67 | 21.33 |
| **1999** | 7.55 | 30.95 | 25.04 | 19.63 |
| **2000** | 9.13 | 22.68 | 25.85 | 23.91 |
| **2001** | 9.21 | 21.67 | 29.22 | 22.56 |
| **2002** | 9.15 | 25.67 | 26.47 | 21.97 |
| **2003** | 8.36 | 28.99 | 28.24 | 19.83 |
| **2004** | 8.25 | 30.65 | 27.65 | 19.31 |
| **2005** | 7.91 | 33.71 | 27.33 | 18.00 |
| **2006** | 7.23 | 37.25 | 29.93 | 15.43 |
| **2007** | 6.95 | 37.61 | 31.29 | 13.42 |
| **2008** | 7.42 | 31.87 | 33.54 | 14.98 |
| **2009** | 6.56 | 38.87 | 31.09 | 13.46 |
| **2010** | 6.34 | 39.64 | 32.69 | 12.68 |
| **2011** | 5.62 | 39.33 | 38.67 | 8.49 |
| **2012** | 4.11 | 40.84 | 39.78 | 8.82 |
| **2013** | 3.84 | 40.61 | 42.87 | 6.16 |
| **2014** | 4.40 | 39.29 | 46.48 | 4.96 |
| **2015** | 2.02 | 38.44 | 49.97 | 4.80 |
| **2016** | 4.24 | 32.91 | 55.28 | 3.70 |
| **2017** | 4.21 | 35.38 | 54.74 | 2.44 |
| **2018** | 3.83 | 33.11 | 59.41 | 1.78 |
| **2019** | 2.17 | 40.70 | 54.87 | 1.15 |
| **Average** | 6.15 | 34.29 | 36.78 | 12.67 |

Source:

Figure 5: The Share (%) of major cereals and millets (Paddy, Wheat, Maize and Jowar) in the total Cereals and Millets grown in the Chhindwara district of Madhya Pradesh from 1998-2019

**Source:**

**4.3. Growth in the Gross Cropped Area under major cereals and millets**

Table 5 below show the signifies that Paddy and Jowar had negative Growth rates whereas Wheat and Maize showed a positive growth. The Paddy and Jowar had an average annual growth rate of -0.02 per cent and -0.10 per cent respectively whereas Wheat and Maize had an Average Annual Growth Rate of 0.04 per cent and 0.09 per cent respectively. Paddy and Jowar showed a negative Simple Growth Rate of -2.48 per cent and -7.88 per cent respectively whereas Wheat and Maize had a simple growth rate of 4.97 per cent and 8.38 per cent respectively during the study period. Overall, Maize had the highest growth rate followed by wheat. Dwivedi *et al*., (2024), carried out a study to estimate the trend and growth rate of area of small millets in Madhya Pradesh between 1966-67 to 2020-21 by using descriptive statistics and linear growth rates (Compound Annual Growth Rate). A decreasing trend was observed and the results showed that the cultivated area has reduced by 5.34 % per annum. The overall area under small; millets reduced from 1,677.7 thousand hectares to 68 thousand hectares. 95 % area was lost due to over-cultivation of major cereals, pulses and cash crops.

Table 5: Slope, Average Annual Growth Rate and Simple Growth Rate of Major cereals and Millets (Paddy, Wheat, Maize and Jowar) in the Chhindwara district of Madhya Pradesh.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of Crops** | **b value** | **AAGR** | **SGR** |
| **Paddy** | -485.87 | -0.02 | -2.48 |
| **Wheat** | 5992.90 | 0.04 | 4.97 |
| **Maize** | 11461.00 | 0.09 | 8.38 |
| **Jowar** | -2999.00 | -0.10 | -7.88 |

Source : Research Findings (2025)

**4.4. Instability in Gross Cropped Area under the major cereals and millets**

It was found that as per the criteria of instability set by CDVI, the growth in Gross Cropped Area under Jowar was found to be the most stable with an instability of just 6.49 per cent. Wheat and Paddy were found to have medium instability with 20.06 per cent and 30.11 per cent. Maize was found to be highly instable with a CDVI of 30.11 per cent. Yamuna *et al.,* (2024) studied the trends and Instability in area of millets in India over a span of 54 years from 1966-67 to 2019-20. Results showed an alarming decline in cultivation area of major millets (-2.51 % for Sorghum and -1.84% for Finger Millet). This was due to over cultivation of major crops. Coefficients of Variation and Cuddy-Della Valle Index was used to find out the instability of Millets which showed varying stability ranging from 5.90 to 21.11. The instability was low in all the millets (almost less than 15) showcasing the resilience and adaptability of millets to diverse climatic conditions. The variability in trend and stability indices among different millet categories emphasizes the need for targeted interventions to address specific challenges faced by each crop.

Table 6:The value of Cuddy-Della Valle Instability Index (CDVI) for Gross Cropped Area of major cereals and millets (Paddy, Wheat, Maize and Jowar) in Chhindwara district of Madhya Pradesh

|  |  |
| --- | --- |
| **Type of Crops** | **CDVI (%)** |
| **Paddy** | 16.39 |
| **Wheat** | 20.06 |
| **Maize** | 30.11 |
| **Jowar** | 6.49 |

Source : Research Findings (2025)

**5.0. CONCLUSION**

The present study highlights the Trend, Growth and Instability of major cereals and millets in Chhindwara district of Madhya Pradesh. The area under cereals and millets grew from 41.21% to 45.70% from TE 2000 to TE 2019. Four major crops—Paddy, Wheat, Maize, and Jowar, accounted for over 90% of the Total Cropped Area. Chhindwara district contributed the most in the state, making up around 4% of the total cereals and millets area. The share of cereals and millets in Gross Cropped Area rose from 48.22% to 78.63% within Chhindwara. Maize held the highest share of area among cereals and millets (36.78%), followed by wheat (34.29%), Jowar (12.67%), and paddy (6.15%). The area under Paddy and Jowar declined. In contrast, maize and wheat increased. Maize had the highest overall growth followed by Wheat. Jowar and Paddy declined significantly. Maize was found to be the most unstable (30% instability index). Wheat and paddy showed moderate instability while Jowar remained the most stable. The examination of these trends is instrumental in the development of policies that will enhance yield and revive the decline.

To ensure sustainable agriculture in Chhindwara district, Paddy and Wheat cultivation should be regulated due to their long-term impact on soil fertility. Promoting crop rotation, especially with legumes, can help restore soil health. With the growing area under cereals and millets, building storage facilities is crucial to minimize post-harvest losses. Despite their health benefits, millets like Jowar and Bajra are declining and need greater promotion. Given the water demands of Paddy and Wheat, better irrigation resource management and recharge efforts are essential. As maize has shown the highest area and growth, setting up a corn processing plant is recommended, though its expansion should be controlled due to high instability. (Please rewrite the conclusion with the research objectives and the findings for other scholars)

**6.0. RECOMMENDATIONS**

6.1. Recommendations to the study

6.2. Recommendations to the future researchers

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