**Absolute and relative change and Instability in Area, Production and Productivity of Chickpea in different agro-climatic regions of Madhya Pradesh, India**

**Abstract**

The present study analysed both absolute and relative changes across different agro-climatic zones during the study period from 1998–99 to 2022–23. The analysis was conducted separately for two Phases - Phase I (pre-NFSM) from 1998–99 to 2007–08 and Phase II (post-NFSM) from 2008–09 to 2022–23 along with an overall assessment of the entire period. Study reveals that the absolute change in chickpea area and production was significant increased occurred in the Nimar plains with an augmentation of 227.92 thousands hectares and 433.71 thousand hectares respectively. The absolute change in chickpea productivity across various agro-climatic zones of Madhya Pradesh has the maximum rise observed in the Kymore Plateau 6723.33 Kg/ha. Regarding productivity for the overall period, a general trend of stability was maintained across most zones from which Malwa Plateau (4.07%) displayed the most consistent productivity.

**Key words-** absolute change, relative change, Instability, agro-climatic zone

1. **INTRODUCTION**

India is the largest producer, contributing over 70% to global chickpea output (FAO, 2023). Chickpea fits well into cereal-based crop rotations, particularly after wheat or rice, and has relatively low input requirements, making it suitable for sustainable and dryland agriculture. Recent studies emphasize chickpea’s potential under changing climatic scenarios due to its moderate drought tolerance and soil-enriching characteristics (Agarwal et al., 2024; ICAR-IIPR, 2023). Chickpea (*Cicer arietinum* L.) is one of the most significant pulse crops globally, contributing to food security, nutritional balance, and soil fertility in dryland agriculture. In 2022, chickpea was cultivated over an estimated 14.8 million hectares worldwide, with total production reaching approximately 18.0 million tonnes and an average productivity of 1,221 kg/ha. Countries such as Jordan, China, and Sudan significantly outperformed global productivity averages, recording yields of 11,878 kg/ha, 5,576 kg/ha, and 4,047 kg/ha, respectively. India maintained its global leadership in chickpea cultivation in 2022, accounting for nearly 73% of the global area (10.47 million hectares) and around 75% of total global production (13.54 million tonnes). However, its average productivity stood at only 1,261 kg/ha, far below many leading producers. The existing yield gap highlights challenges such as limited irrigation coverage, low adoption of high-yielding varieties, and frequent pest infestations. Nonetheless, chickpea remains central to India’s rabi cropping system, particularly in semi-arid and rain-dependent zones. Chickpeas are not only consumed as pulses but also find their way into various snacks, sweets, and condiments in their dried form. Furthermore, the fresh green variant of chickpeas serves as a nutritious vegetable. (Rawat *et al.* 2023).

Within India, Madhya Pradesh stands as the leading chickpea-producing state, recording an area of 3.55 million hectares and a production of 4.56 million tonnes during 2022–23, with an average productivity of 1,285 kg/ha—slightly above the national average. The state’s dominance is attributed to its favorable agro-climatic conditions, especially in the Vindhyan Plateau and Central Narmada Valley. However, challenges such as erratic rainfall, declining soil fertility, and inadequate access to quality inputs continue to hinder productivity growth. The districts with the highest chickpea output are Chhindwara, Rajgarh, and Ujjain, while key producing regions include the eastern Malwa Plateau, Bundelkhand Plateau, and the upper-Central Narmada Valley. At the national level, chickpea is a major rabi pulse crop, occupying about 30% of the total pulse area and contributing 38% of the annual pulse production. In Madhya Pradesh, chickpea is considered the most economically significant pulse crop due to its dominance in terms of both area and market value.Present study is important for assessing inter-zonal disparities in Chick pea across Madhya Pradesh. The ecological and policy diversity of the state presents a valuable opportunity to analyze absolute and relative changes in area, production, and productivity, and to determine the impact of public schemes on sustainable growth. This study will be undertaken with the following objectives.

1. **Objectives**
2. To examine the zone wise absolute and relative change in area, production, productivity of chickpea in different agro climatic regions of Madhya Pradesh.
3. To examine the Instability of area, production and productivity of chick pea in various agro- climatic regions of Madhya Pradesh.
4. **RESEARCH METHODOLOGY**

The analysis is based on data pertaining to area, production, and productivity of chickpea covering 25-year period from 1998–99 to 2022–23. For the purpose of regional analysis, the state of Madhya Pradesh is classified into 11 agro-climatic zones. Each of these agro-climatic zones comprises specific districts, and they display considerable variation in chickpea cultivation in terms of area, production and productivity.

**3.1: Absolute and Relative change:** Absolute changes as well as relative changes in area, production and productivity of chickpea were estimated in the present study.

**3.1.1: Absolute change:** Absolute growth Rate measures the actual increase or decrease in a variable (such as area, production, or productivity) over a specific time period.

**Absolute change = Yn – Y0**

Where,

Yn = Mean value (area, production and productivity) for the last triennium ending

Y0 = Mean value (area, production and productivity) for the first (base) triennium ending

**3.1.2: Relative growth rate:** Measures the percentage change in area, production, or productivity over a specific period relative to the base period**.**

**Relative change = ( )×100**

Where,

Yn = Mean value (area, production and productivity) for the last triennium ending

Yo = Mean value (area, production and productivity) for the first (base) triennium ending

**3.2 Extent of Variability:** The extent of variability indicates how much the values (area, production, or productivity) fluctuate over a period of time.

**Coefficient of Variation**

To quantify the extent of variability in area, production, and productivity of major pulses across agro-climatic zones, the Coefficient of variation was computed for each parameter and crop under study.

**Coefficient of Variation= σ/X×100**

σ = Standard deviation of the observations over the study period

X = Arithmetic mean of the observations

For robust interpretation, zones were rigorously categorized based on their CV values: for CV less than (15%), 'moderately fluctuated' for CV between (15% and 30%,) and 'highly fluctuated' for CV exceeding (30%.)

**Comparative Phase-wise- (Pre and Post-NFSM)**

The study period was divided into two phases based on the implementation of the **National Food Security Mission (NFSM)**

* Phase I: **1998–99 to 2006–07 (Pre-NFSM)**
* Phase II: **2007–08 to 2022–23 (Post-NFSM)**

1. **Result**

**4.1:** **Absolute and Relative changes in the area, production, and productivity of Chick pea**

**4.1.1: Phase - I (1998-99 to 2007-08) Pre NFSM**

In Phase Ⅰ, the analysis of Table 1 revealed that the absolute change in chickpea area across various agro-climatic zones of Madhya Pradesh has increased in the current year compared to the baseline. The most increased occurred in the Vindhyan Plateau, with an augmentation of 223.52 thousand hectares, followed by the Kymore Plateau 90.35 thousand hectares and the Malwa Plateau at 54.26 thousand hectares, Conversely, a decline was noted in the Gird region with a reduction of 74.77 thousand hectares followed by Bundelkhand zone at 21.77 thousand hectares and the Nimar plains at 12.18 thousand hectares. The relative change in area was determined to be highest in Chhattisgarh plain at 39.59% followed by the Vindhyan Plateau (36.77%) and the Satpura Plateau (29.70%). While it declines was noted in Nimar plains with a reduction of (21.10%) followed by Gird region (19.37%) and Bundelkhand region at (14.87%).

The absolute change in chickpea production across various agro-climatic zones of Madhya Pradesh had the maximum rise observed in the Vindhyan Plateau 166.70 thousand hectares, followed by the kymore Plateau 52.68 thousand hectares, and the Malwa Plateau 41.85 thousand hectares, While it declines was noted in Gird region with a reduction 101.08 thousand hectares followed by Bundelkhand zone at 57.49 thousand hectares and the Nimar plains at 4.69 thousand hectares. The relative change in production was determined to be highest in Satpura Plateau at (56.78%) followed by the Chhattisgarh plain (34.74%) and the Jhabua hill zone (32.43%). While it declines was noted in Bundelkhand region with a reduction of (32.10%) followed by Gird region (27.05%) and Nimar plains at (9.02%).

The absolute change in chickpea productivity across various agro-climatic zones of Madhya Pradesh Has the maximum rise observed in the Nimar plains 1333.33 Kg/Ha, followed by the Jhabua hill zone 510.00 Kg/Ha and the Malwa Plateau 363.33 Kg/Ha, While it decline was noted in Bundelkhand region with a reduction910 Kg/Ha followed by kymore Plateau at 343.33 Kg/Ha and the Vindhyan Plateau 73.33 Kg/Ha .The relative change in productivity was determined to be highest in Jhabua hill zone at (47.81% )followed by the Nimar plains (44.49%) and the Satpura Plateau (21.21%) While it decline was noted in Bundelkhand region with a reduction of (23.68%) followed by Kymore Plateau ( 6.79%) and Chhattisgarh Plateau (2.80%).

4.1.2: **Phase Ⅱ (2008-09 to 2022-23) Post NFSM**

In Phase Ⅱ has the analysis of Table 1 revealed that the absolute change in chickpea area across various agro-climatic zones of Madhya Pradesh Has increased in the current year compared to the baseline. The most significant increased occurred in the Nimar plains with an augmentation of 231.11 thousands hectares, followed by the Northern hill region of Chhattisgarh at 75.61 thousands hectares and the Chhattisgarh plain at 43.48 thousand hectares, Conversely , a decline was noted in the Malwa Plateau ,with a reduction of 499.24 thousand hectares followed by Vindhyan Plateau at 350.31 thousand hectares and the Kymore Plateau at 174.47 thousand hectares.The relative change in area was determined to be highest in Chhattisgarh plain at (611.28%) followed by the Nimar plains (423.87%) and the Northern hill region of Chhattisgarh (165.33 %) While it decline was noted in Malwa Plateau with a reduction of( 62.86%) followed by Kymore Plateau 44.08% and Vindhyan Plateau (42.46%).

The absolute change in chickpea production Has the maximum rise observed in the Nimar plains 426.50 thousand hectares, followed by the Northern hill region of Chhattisgarh 126.63 thousand hectares, and the Satpura Plateau 105.39 thousand hectares, while it declines was noted in Malwa Plateau with a reduction 243.38 thousand hectares followed by Gird region at 28.17 thousand hectares and the Vindhyan Plateau at 23.61 thousand hectares. The relative change in production was determined to be highest in Chhattisgarh plain at (955.79%) followed by the Nimar plains (720.08%) and the Northern hill region of Chhattisgarh (592.65%). While it declines was noted in Malwa Plateau with a reduction of (34.85%) followed by Gird region (8.22%) and Vindhyan Plateau (2.93%).

The absolute change in chickpea Productivity has the maximum rise observed in Kymore Plateau (6640.00 Kg/Ha), followed by the Malwa Plateau (6336.67 Kg/Ha) and the Northern hill region of Chhattisgarh (5356.67 Kg/Ha), While its decline was noted in Chhattisgarh Plateau with a reduction of 493.33 Kg/Ha followed by Central Narmada valley (956.67 Kg/Ha) and the Satpura Plateau (1486.67 Kg/Ha) .The relative change in productivity was determined to be highest in Northern hill region of Chhattisgarh at 201.88% followed by the Kymore Plateau (129.27%) and the Bundelkhand region (100.63%). While its decline was noted in Central Narmada valley with a reduction of 37.22% followed by Gird region (50.35%) and Chhattisgarh plains.

**Table 1: Absolute and Relative change in the area, production and productivity of Chickpea in Phase -Ⅰ(1998-99 to 2007-08) Pre NFSM & Phase Ⅱ(2008-09 to 2022-23) Post NFSM**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.no.** | **Agro-climatic Zone** | **Phase Ⅰ (1998-99 to2007-08) Before NFSM** | | | | | | **Phase Ⅱ(2008-09 to 2022-23)** | | | | | |
| **Area (000,ha)** | | **Production (000,MT)** | | **Productivity (Kg/Ha)** | | **Area (000,ha)** | | **Production (000,MT)** | | **Productivity (kg/ha)** | |
|  | **Absolute Change** | **Relative change** | **Absolute Change** | **Relative change** | **Absolute Change** | **Relative change** | **Absolute Change** | **Relative change** | **Absolute Change** | **Relative change** | **Absolute Change** | **Relative change** |
| **1** | **Chhattisgarh plains** | 2.05 | 39.59 | 1.51 | 34.74 | -23.33 | -2.80 | 43.48 | 611.28 | 65.80 | 955.79 | 493.33 | 51.03 |
| **2** | **Northen hill region of Chhattisgarh** | 2.79 | 12.55 | -0.55 | -4.46 | 166.67 | 7.72 | 75.61 | 165.33 | 126.63 | 592.65 | 5356.67 | 201.88 |
| **3** | **Kymore Plateau** | 90.35 | 27.56 | 52.68 | 22.21 | -343.33 | -6.79 | -174.47 | -44.08 | 73.49 | 23.61 | 6640.00 | 129.27 |
| **4** | **Vindhyan Plateau** | 223.52 | 36.77 | 166.70 | 28.97 | -73.33 | -1.31 | -350.31 | -42.46 | -23.73 | -2.93 | 3953.33 | 68.83 |
| **5** | **Central Narmada Valley** | 0.90 | 0.49 | -1.56 | -0.74 | 100.00 | 4.42 | -31.95 | -20.09 | 25.02 | 12.75 | 956.67 | 37.22 |
| **6** | **Gird region** | -74.77 | -19.37 | -101.08 | -27.05 | 266.67 | 3.99 | -130.27 | -41.35 | -28.17 | -8.22 | 4116.67 | 50.35 |
| **7** | **Bundelkhand region** | -21.77 | -14.87 | -57.49 | -32.10 | -910.00 | -23.68 | -31.78 | -22.54 | 47.00 | 32.38 | 3206.67 | 100.63 |
| **8** | **Satpura Plateau** | 14.77 | 29.70 | 21.44 | 56.78 | 316.67 | 21.21 | 31.39 | 42.48 | 105.39 | 150.20 | 1486.67 | 77.84 |
| **9** | **Malwa Plateau** | 54.26 | 11.72 | 41.85 | 9.74 | 363.33 | 5.36 | -499.24 | -62.86 | -243.38 | -34.85 | 6336.67 | 91.18 |
| **10** | **Nimar plains** | -12.18 | -21.10 | -4.69 | -9.02 | 1333.33 | 44.49 | 231.11 | 423.87 | 426.50 | 720.08 | 4296.67 | 97.58 |
| **11** | **Jhabua hill zone** | -1.53 | -2.37 | 13.04 | 32.43 | 510.00 | 47.81 | -15.27 | -14.10 | 22.69 | 21.98 | 1703.33 | 77.78 |

**Table 2 Absolute and relative change in the area, production, and productivity of chickpea over the study period (1998-99 to 2022-23)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **S.No.** | **Agroclimatic Zone** | **Area (000,ha)** | | **Production (000,MT)** | | **Productivity (kg/ha)** | |
| **Absolute Change** | **Relative change** | **Absolute Change** | **Relative change** | **Absolute Change** | **Relative change** |
| **1** | **Chhattisgarh plains** | 45.42 | 877.40 | 68.34 | 1572.90 | 626.67 | 75.20 |
| **2** | **Northen hill region of Chhattisgarh** | 99.10 | 445.55 | 135.57 | 1090.83 | 5850.00 | 270.83 |
| **3** | **Kymore Plateau** | -106.55 | -32.50 | 147.55 | 62.22 | 6723.33 | 133.05 |
| **4** | **Vindhyan Plateau** | -133.01 | -21.88 | 210.41 | 36.56 | 4096.67 | 73.15 |
| **5** | **Central Narmada Valley** | -55.42 | -30.37 | 10.97 | 5.22 | 1263.33 | 55.82 |
| **6** | **Gird region** | -201.27 | -52.14 | -59.25 | -15.85 | 5610.00 | 83.94 |
| **7** | **Bundelkhand region** | -37.19 | -25.40 | 13.11 | 7.32 | 2550.00 | 66.35 |
| **8** | **Satpura Plateau** | 55.56 | 111.69 | 137.80 | 364.85 | 1903.33 | 127.46 |
| **9** | **Malwa Plateau** | -168.17 | -36.31 | 25.61 | 5.96 | 6506.67 | 95.97 |
| **10** | **Nimar plains** | 227.92 | 394.96 | 433.71 | 833.68 | 5703.33 | 190.32 |
| **11** | **Jhabua hill zone** | 28.34 | 43.83 | 85.70 | 213.08 | 2826.67 | 265.00 |

**4.1.3: Over the study period (1998-99 to 2022-23)**

In over the study period analysis of Table 2 reveals that the absolute change in chickpea area The most significant increased occurred in the Nimar plains , with an augmentation of 227.92 thousands hectares, followed by the Northern hill region of Chhattisgarh 99.10 thousands hectares and the Satpura Plateau at 55.56 thousand hectares, Conversely , a decline was noted in the Gird region ,with a reduction of 201.27 thousand hectares followed by Malwa region at 168.17 thousand hectares and the Vindhyan Plateau 133.01 thousand hectares. The relative change in area was determined to be highest in Chhattisgarh plain at 877.40% followed by the Northern hill region of Chhattisgarh 445.55% and the Nimar plains 394.96%. While its decline was noted in Gird region with a reduction of 52.14% followed by Malwa Plateau (36.31%) and Kymore Plateau (32.50%).

The absolute change in chickpea production across various agro-climatic zones of Madhya Pradesh Had the maximum rise observed in the Nimar plains 433.71 thousand hectares followed by the Vindhyan Plateau 210.41 thousand hectares, and the Kymore Plateau 147.55 thousand hectares, While it decline was noted in Gird region with a reduction 59.25 thousand hectares followed by central Narmada valley 10.97 thousand hectares and the Bundelkhand region 13.11 thousand hectares. The relative change in production was determined to be highest in Chhattisgarh plain1572.90 % followed by the Northern hill region of Chhattisgarh 1090.83% and the Nimar plains 833.68%. While it decline was noted in Gird region with a reduction of 15.85% followed by Central Narmada valley 5.22% and Malwa Plateau 5.96%.

The absolute change in chickpea productivity across various agro-climatic zones of Madhya Pradesh Has the maximum rise observed in the Kymore Plateau 6723.33 Kg/Ha, followed by the Malwa Plateau 6506.67 Kg/Ha and the Northern hill region of Chhattisgarh 5850.00 Kg/Ha, While it decline was noted in Chhattisgarh Plateau with a reduction 626.67 Kg/Ha followed by Central Narmada valley 1263.33 Kg/Ha and the Satpura Plateau 1903.33 Kg/Ha .The relative change in productivity was determined to be highest in Northern hill region of Chhattisgarh at 270.83% followed by the Jhabua hill zone265.00% and the nimar plain 190.32% While it decline was noted in Central Narmada valley with a reduction of 55.82% followed by Bundelkhand region 66.35% and Vindhyan Plateau 73.15%.

**4.2:** **Analysis of variability in area, production, and productivity of Chickpea across Agro-Climatic Zones of Madhya Pradesh**

**4.2.1: Phase I (1998-99 to 2007-08 pre-NFSM)**

During Phase I the stability of chickpea area under cultivation exhibited discernible variations across the agroclimatic zone. The Northern hill region of Chhattisgarh (6.12%) demonstrated unparalleled stability, closely trailed by Kymore Plateau (6.53%), Malwa Plateau (7.96%), Vindhyan Plateau (7.99%), Satpura Plateau (9.97%), and the Chhattisgarh plains (14.93%), all of which sustained a commendable level of area consistency. Conversely, a cohort of zones experienced moderate fluctuations in cultivated area: the Gird region (15.06%), Bundelkhand region (17.55%), Nimar plains (18.23%), Central Narmada Valley (20.87%), and notably, the Jhabua hill zone (27.59%), which registered the highest degree of moderate variability. Intriguingly, no zones were classified as highly fluctuated for area during this foundational period.

Pertaining to production stability during Phase 1, a substantial majority of zones gravitated towards the stable category. Kymore Plateau (7.77%) and Vindhyan Plateau (8.51%) evinced remarkable consistency in output, succeeded by the Northern hill region of Chhattisgarh (8.95%), Malwa Plateau (9.15%), and the Gird region (13.72%). Moderate fluctuations in production were recorded across the Chhattisgarh plains (15.77%), Bundelkhand region (16.40%), Central Narmada Valley (19.36%), Nimar plains (22.77%), and Satpura Plateau (23.11%). Standing as an outlier, the Jhabua hill zone (33.19%) emerged as the singular highly fluctuated zone for chickpea production in this Phase, indicative of pronounced output instability.

The productivity of chickpea in Phase 1 generally underscored a pervasive degree of stability across most zones. Malwa Plateau (3.24%) exemplified the most unwavering productivity, with the Gird region (3.48%), Vindhyan Plateau (3.70%), Kymore Plateau (4.23%), Northern hill region of Chhattisgarh (5.34%), Chhattisgarh plains (6.24%), Bundelkhand region (6.77%), Central Narmada Valley (7.11%), Nimar plains (7.74%), and Jhabua hill zone (13.44%) likewise achieving consistent yield per unit area. Solely the Satpura Plateau (18.56%) encountered moderate fluctuations in productivity, signifying a relatively uniform output efficiency across the residual regions. Importantly, no zones ascended to the highly fluctuated classification for productivity during this Phase.

**4.2.2: Phase II (2008-09 to 2022-23 post-NFSM)**

Table no.3 Shows that Kymore Plateau (7.45%) Vindhyan Plateau (7.97%), Malwa Plateau (8.21%), Gird region (12.79%), and Satpura Plateau (12.96%) collectively demonstrated sustained stability in their cultivated area. Concurrently, several zones experienced moderate fluctuations in area: the Northern hill region of Chhattisgarh (15.49%), Central Narmada Valley (16.66%), Nimar plains (19.79%), and Bundelkhand region (26.98%). Alarmingly, the Chhattisgarh plains (72.68%) and Jhabua hill zone (33.74%) were definitively categorized as highly fluctuated zones for area, signifying substantial volatility in the extent of chickpea cultivation.

The production trajectories in Phase II, likewise presented a nuanced tableau of stability and instability. The Malwa Plateau (8.82%), Vindhyan Plateau (8.97%), and Kymore Plateau (9.75%) and Gird region (12.20%), successfully maintained stable production levels. Moderate fluctuations in production were observed in the Central Narmada Valley (16.65%), Northern hill region of Chhattisgarh (18.30%), Satpura Plateau (22.31%), and Nimar plains (22.61%). A profound concern materialized with Bundelkhand region (32.19%), Jhabua hill zone (35.64%), and with the highest fluctuation occurred in Chhattisgarh plains (86.35%), all of which endured highly fluctuated production, underscoring considerable volatility in chickpea output.

Regarding productivity in Phase II, a majority of zones largely sustained their stability, indicative of consistent yields. Malwa Plateau (3.58%) exemplified paramount stability, closely followed by Gird region (3.66%), Vindhyan Plateau (4.86%), Kymore Plateau (5.88%), Nimar plains (7.60%), Central Narmada Valley (8.28%), Northern hill region of Chhattisgarh (9.21%), Bundelkhand region (10.26%), and Jhabua hill zone (10.88%), all consistently demonstrating stable productivity. Only the Satpura Plateau (22.05%) and Chhattisgarh plains (29.76%) recorded moderate fluctuations in productivity, suggesting some variability in yields per unit area, yet no zones transgressed into the highly fluctuated classification for productivity during this period.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **S.No.** | **Agro-climatic Zone** | **Phase 1(1998-99 to 2007-08 pre NFSM** | | | **Phase 2(2008-09 to 2022-23) Post NFSM** | | |
| **coefficient of variance (%)** | | | **coefficient of variance (%)** | | |
| **Area**  **%** | **Production**  **%** | **Productivity**  **%** | **Area**  **%** | **Production %** | **Productivity**  **%** |
| 1 | Chhattisgarh plains | 14.93 | 15.77 | 6.24 | 72.68 | 86.35 | 29.76 |
| 2 | Northen hill region of Chhattisgarh | 6.12 | 8.95 | 5.34 | 15.49 | 18.30 | 9.21 |
| 3 | Kymore Plateau | 6.53 | 7.77 | 4.23 | 7.45 | 9.75 | 5.88 |
| 4 | Vindhyan Plateau | 7.99 | 8.51 | 3.70 | 7.97 | 8.97 | 4.86 |
| 5 | Central Narmada Valley | 20.87 | 19.36 | 7.11 | 16.66 | 16.65 | 8.28 |
| 6 | Gird region | 15.06 | 13.72 | 3.48 | 12.79 | 12.20 | 3.66 |
| 7 | Bundelkhand region | 17.55 | 16.40 | 6.77 | 26.98 | 32.19 | 10.26 |
| 8 | Satpura Plateau | 9.97 | 23.11 | 18.56 | 12.96 | 22.31 | 22.05 |
| 9 | Malwa Plateau | 7.96 | 9.15 | 3.24 | 8.21 | 8.82 | 3.58 |
| 10 | Nimar plains | 18.23 | 22.77 | 7.74 | 19.79 | 22.61 | 7.60 |
| 11 | Jhabua hill zone | 27.59 | 33.19 | 13.44 | 33.74 | 35.64 | 10.88 |

**Table 3: Analysis of Coefficient of Variance in Area, Production, and Productivity of Chickpea Across Agro-Climatic Zones of Madhya Pradesh during Phase I (1998-99 to 2007-08 pre-NFSM) and Phase II (2008–09 to 2022–23): Post-NFSM**

**4.2.3: Overall Period (1998-99 to 2022-23)**

Across the overall period, the stability of chickpea area under cultivation exhibited significant variability among the agroclimatic zones. Kymore Plateau (7.13%) demonstrated the highest level of stability, followed closely by Vindhyan Plateau (7.98%), Malwa Plateau (8.38%), and Gird region (14.12%), all maintaining commendable consistency in their cultivated area. A substantial number of zones experienced moderate fluctuations in area: Northern hill region of Chhattisgarh (19.11%), Satpura Plateau (18.05%), Bundelkhand region (23.29%), Central Narmada Valley (24.42%), and Nimar plains (22.94%). Critically, Chhattisgarh plains (99.99%) and Jhabua hill zone (37.42%) were classified as highly fluctuated zones for area, indicating pronounced volatility in the extent of chickpea cultivation over the entire period.

Pertaining to production stability across the overall period, a mixed performance was observed. Vindhyan Plateau (9.09%), Malwa Plateau (9.60%), Kymore Plateau (9.78%), and Gird region (12.73%) evinced commendable consistency in chickpea output, falling within the stable category. Several zones registered moderate fluctuations in production: Central Narmada Valley (22.59%), Northern hill region of Chhattisgarh (24.64%), Bundelkhand region (26.11%), Nimar plains (28.07%), and Satpura Plateau (33.48%). Notably, the Satpura Plateau, while on the higher end of moderate, indicates a greater degree of variability. The Jhabua hill zone (43.73%) and Chhattisgarh plains (121.23%) emerged as highly fluctuated zones for chickpea production, underscoring severe instability in their output over the entire span.

Regarding productivity for the overall period, a general trend of stability was maintained across most zones. Malwa Plateau (4.07%) displayed the most consistent productivity, closely followed by Gird region (4.25%), Vindhyan Plateau (5.27%), Kymore Plateau (6.66%), Nimar plains (9.24%), Bundelkhand region (9.40%), Northern hill region of Chhattisgarh (10.93%), Central Narmada Valley (12.52%), and Jhabua hill zone (14.43%), all of which achieved stable yields per unit area. Only the Chhattisgarh plains (30.49%) and Satpura Plateau (25.92%) were categorized as moderately fluctuated in terms of productivity, suggesting some variability in their yield efficiency. No zones were classified as highly fluctuated for productivity during this comprehensive period.

**Table 4: Analysis of Coefficient of Variance in Area, Production, and Productivity of Chickpea Across Agro-Climatic Zones of Madhya Pradesh in Overall Period (1998-99 to 2022-23)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No.** | **Agro-climatic Zone** | **Coefficient of variance % (1998-99 to 2022-23) overall period** | | |
| **Area** | **Production** | **Productivity** |
|
|
| 1 | Chhattisgarh plains | 99.99 | 121.23 | 30.49 |
| 2 | Northen hill region of Chhattisgarh | 19.11 | 24.64 | 10.93 |
| 3 | Kymore Plateau | 7.13 | 9.78 | 6.66 |
| 4 | Vindhyan Plateau | 7.98 | 9.09 | 5.27 |
| 5 | Central Narmada Valley | 24.42 | 22.59 | 12.52 |
| 6 | Gird region | 14.12 | 12.73 | 4.25 |
| 7 | Bundelkhand region | 23.29 | 26.11 | 9.40 |
| 8 | Satpura Plateau | 18.05 | 33.48 | 25.92 |
| 9 | Malwa Plateau | 8.38 | 9.60 | 4.07 |
| 10 | Nimar plains | 22.94 | 28.07 | 9.24 |
| 11 | Jhabua hill zone | 37.42 | 43.73 | 14.43 |

**5: Discussion**

During Phase I, the Vindhyan Plateau exhibited the most significant absolute increase in both chickpea area (223.52 thousand hectares) and production (166.70 thousand tonnes). Concurrently, the Chhattisgarh plains showed the highest relative increase in area (39.59%). In terms of productivity, the Jhabua hill zone recorded the highest relative increase at 47.81%, while the Nimar Plains showed the largest absolute increase (1333.33 kg/ha). Conversely, the Gird region experienced the most notable absolute decline in both area (74.77 thousand hectares) and production (101.08 thousand tonnes), and also the highest relative decline in area (19.37%). The Bundelkhand region saw the most significant absolute and relative decline in productivity (910.00 kg/ha and 23.68% respectively).

During Phase II, the Nimar Plains exhibited the most significant absolute increase in both chickpea area (231.11 thousand hectares) and production (426.50 thousand tonnes). Concurrently, the Chhattisgarh Plain showed the highest relative increase in area (611.28%) and production (955.79%). In terms of productivity, the Kymore Plateau recorded the highest absolute increase at 6640.00 kg/ha, while the Northern Hill Region of Chhattisgarh showed the highest relative increase at 201.88%. Conversely, the Malwa Plateau experienced the most notable absolute decline in both area (499.24 thousand hectares) and production (243.38 thousand tonnes), also showing the highest relative decline in both area (62.86%) and production (34.85%). The Satpura Plateau saw the largest absolute decline in productivity (1486.67 kg/ha), and the Gird Region recorded the highest relative decline in productivity (50.35%).

Over the entire study period, the Nimar Plains exhibited the most significant absolute increase in chickpea area (227.92 thousand hectares) and production (433.71 thousand tonnes). Northern hill region of chhattisgarh most significant relative increase (445.55) Concurrently, the Chhattisgarh Plain showed the highest relative increase in area (877.40%) and production (1572.90%). In terms of productivity, the Kymore Plateau recorded the highest absolute increase at 6723.33 kg/ha, while the Northern Hill Region of Chhattisgarh showed the highest relative increase at (270.83%). Conversely, the Gird Region experienced the most notable absolute decline in both area (201.27 thousand hectares) and production (59.25 thousand tonnes), also showing the highest relative decline in area (52.14%) and production (15.85%). For productivity, the Satpura Plateau saw the largest absolute decline (1903.33 kg/ha), and the Vindhyan Plateau recorded the highest relative decline (73.15%). Similar result was reported by (Srivastava *et.at* 2022)

**5.2: Analysis of Instability in area, production, and productivity of Chickpea across Agro-Climatic Zones of Madhya Pradesh**

Across all the agro climatic conditions, the Kymore Plateau consistently demonstrated the most stable agricultural performance, exhibiting the lowest coefficients of variance (CVs) for Area (6.53% pre-NFSM, 7.45% post-NFSM, 7.13% overall), Production (7.77% pre-NFSM, 9.75% post-NFSM, 9.78% overall), and Productivity (4.23% pre-NFSM, 5.88% post-NFSM, 6.66% overall). Conversely, the Jhabua hill zone was highly unstable pre-NFSM (Area 27.59%, Production 33.19%, Productivity 13.44%), while the Chhattisgarh Plains showed the highest fluctuations in Area (72.68% post-NFSM, 99.99% overall) and Production (86.35% post-NFSM, 121.23% overall) in the latter and overall periods. The Satpura Plateau experienced the most significant instability in Productivity (22.05% post-NFSM, 25.92% overall) in the latter and overall periods, underscoring that the lowest CV signifies the most stable performance. Finding is in consonance with studies conducted by Srivastava et. al (2022)

**Conclusion:**

Over the study period, the Chhattisgarh plains exhibited the most significant increases in chickpea area (877.40%), production (1572.90%), and productivity (75.20%). In contrast, the Gird region experienced the most significant relative declines in area (52.14%) and production (15.85%). This analysis revealed that the Kymore Plateau, with Area (7.13%), Production (9.78%), and Productivity (6.66%), and Malwa Plateau, with Area (8.38%), Production (9.60%), and Productivity (4.07%), were the most stable zones for chickpea cultivation. Conversely, the Chhattisgarh plains, with Area (99.99%), Production (121.23%), and Productivity (30.49%), experienced significant fluctuations.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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