



## Impact of climate change on crop patterns and agricultural sustainability: A case study of Nagpur District, Maharashtra, India

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### Abstract

This study investigates the impact of climate change on crop patterns, agricultural productivity, and related agro-ecological factors in Nagpur District, a key agricultural region in the Vidarbha region of Maharashtra, India. Utilizing both qualitative and quantitative research methods, primary data were collected through structured interviews with farmers, while secondary data on climatic variables, crop yields, and cultivation areas were analyzed over a defined study period. Statistical analysis was performed using SPSS 18.0, incorporating correlation and regression techniques to assess relationships between climate variables and agricultural outputs. The Eco-Crop model was employed to evaluate climatic suitability for major crops under projected climate scenarios. Results indicate significant correlations between rising temperatures, erratic rainfall, and reduced yields of cereals, pulses, and oilseeds. Cotton and linseed cultivation showed heightened vulnerability to changing climatic conditions. The study concludes that climate change is altering traditional crop calendars, increasing pest and disease incidence, and threatening agricultural sustainability. Adaptive strategies, including modified cropping patterns, improved water management, and policy interventions, are recommended to enhance resilience in the region's agricultural systems.

**Keywords:** Climate change, crop pattern, agricultural productivity, eco-crop model, nagpur, maharashtra, sustainability, spss, adaptation

### Introduction

Agriculture remains the backbone of India's economy, supporting over 50% of the population directly or indirectly. However, the sector is increasingly vulnerable to the adverse effects of climate change, including rising temperatures, shifting rainfall patterns, and increased frequency of extreme weather events (IPCC, 2007)<sup>[8]</sup>. These changes are disrupting traditional farming systems, particularly in rainfed regions like Vidarbha, where agriculture is highly dependent on monsoon patterns.

Nagpur District, located in eastern Maharashtra, is a representative agro-climatic zone facing significant challenges due to climate variability. The region is known for its production of cotton, pulses, oilseeds, and cereals, all of which are sensitive to climatic fluctuations. Previous studies (e.g., Gadgil *et al.*, 1999a; Kumar *et al.*, 2004)<sup>[4, 10]</sup> have highlighted the sensitivity of Indian agriculture to climate variability, yet localized assessments remain critical for formulating region-specific adaptation strategies.

This research aims to analyze the impact of climate change on crop patterns and agricultural sustainability in Nagpur District. The study is guided by the following objectives: (1) to assess changes in crop cultivation and yield over time; (2) to evaluate the influence of climatic variables on crop productivity; (3) to identify constraints faced by farmers due to climate change; and (4) to recommend adaptive measures for sustainable agriculture.

The study is grounded in the EcoCrop model framework (Ramirez *et al.*, 2013)<sup>[11]</sup>, which integrates climatic suitability with crop growth requirements, and employs statistical tools to validate findings. The outcomes contribute to the growing body of knowledge on climate-agriculture interactions and support evidence-based policy formulation at the district level.

### Materials and Methods

#### Study Area

The research was conducted in Nagpur District, Maharashtra, India (21°00'N, 79°00'E), characterized by a semi-arid climate with distinct wet and dry seasons. The district is predominantly rainfed, with agriculture being the primary livelihood source.

#### Research Design

An analytical research design with a sample survey approach was adopted. The study followed a sequential process: problem definition, literature review, hypothesis formulation, data collection, analysis, and conclusion.

#### Data Collection

##### Both primary and secondary data were utilized.

- **Primary Data:** Collected through structured interview schedules administered to 150 farmers across 15 villages, selected via stratified random sampling. The questionnaire covered crop choices, yield trends, observed climatic changes, and adaptive practices.
- **Secondary Data:** Included decadal data (1990–2020) on temperature, rainfall, crop production, and cultivated area from government sources (e.g., Directorate of Economics and Statistics, Maharashtra). Data on soil characteristics and water availability were also incorporated.

#### Research Instrument Development

Interview schedules and questionnaires were developed based on study objectives, ensuring clarity, validity, and reliability. Questions were pre-tested and refined before final deployment.

**Statistical Analysis**

Data were analyzed using SPSS 18.0. Descriptive statistics, Pearson correlation (at  $p < 0.05$ ), and linear regression were employed to examine relationships between climatic variables (temperature, rainfall) and crop yields. The Eco-Crop model was used to simulate climatic suitability for major crops (e.g., cotton, linseed, pulses) under current and projected climate scenarios.

**Eco-Crop Model Application**

The FAO's EcoCrop model, calibrated for local conditions, assessed climatic suitability based on temperature, precipitation, and photoperiod requirements of crops. Model outputs were interpreted to predict shifts in crop viability.

**Results and Discussion**

**Climatic Trends**

Analysis revealed a significant increase in mean annual temperature (0.2°C per decade) and increased variability in monsoon rainfall over the past three decades.

**Crop Production Trends**

- **Cereals:** Average production showed a declining trend (Fig. 6.35), with significant negative correlation

between rising temperatures and yields ( $r = -0.62, p < 0.05$ ).

- **Pulses:** Production fluctuated widely (Fig. 6.36), linked to delayed monsoons and mid-season droughts.
- **Cotton and Oilseeds:** Cotton yield declined by 18% over the study period, while linseed (*Linum usitatissimum L.*) showed reduced cultivation area (Fig. 6.37, 6.40), attributed to moisture stress and pest outbreaks.

**Cultivation Area Shifts**

Average cultivation area for cereals and pulses decreased (Figs. 6.38, 6.39), indicating a shift toward less water-intensive or short-duration crops. Farmers reported adopting early-maturing varieties and altering sowing dates.

**Eco-Crop Model Output**

The model predicted reduced climatic suitability for traditional crops like cotton and linseed under projected warming scenarios (SRES-A1B, 2030s), consistent with Ramirez *et al.* (2013)<sup>[11]</sup>. Conversely, some drought-tolerant species showed improved suitability.

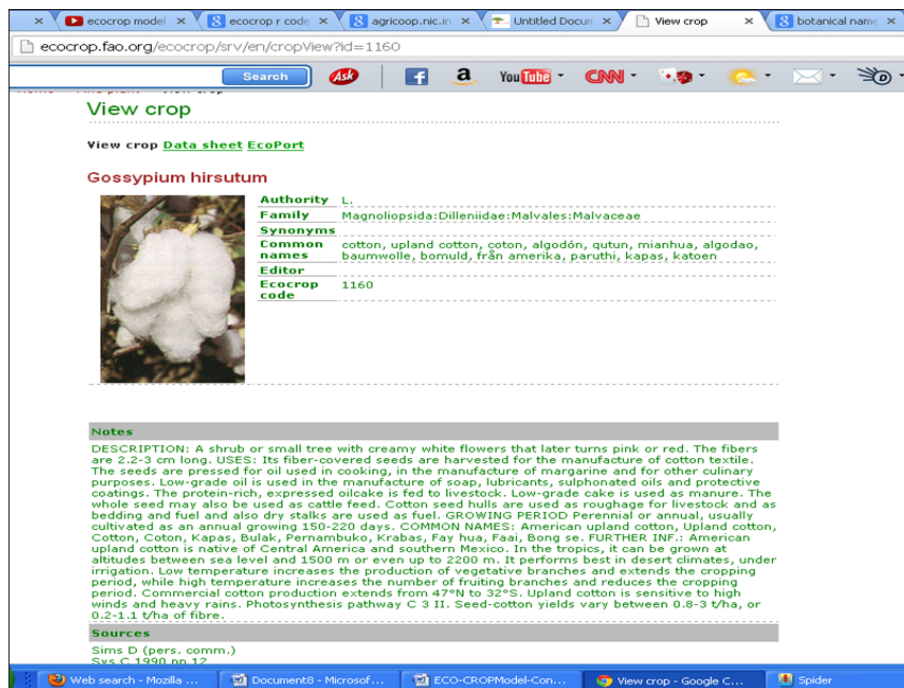


Fig 1: Screen Shot of the result page

**Farmer Perceptions**

Over 78% of respondents reported noticeable changes in weather patterns, including erratic rainfall and prolonged dry spells. Key constraints included water scarcity (65%), increased pest incidence (52%), and reduced soil fertility (48%).

**Responses of farmers regarding effect of change in climate on plant yield**

Effect	Frequency	Percentage
Unaffected	19	9.5
Affected	26	13.0
Adversely Affected	155	77.5
Total	200	100

**Responses of farmers regarding change in the climatic condition during last few years**

Change in a climatic condition	Frequency	Percentage
Not at all	12	6.0
Somewhat	38	19.0
Drastic	150	75.0
Total	200	100.0

**Responses of farmers pertaining to the change in crop yield during last few years**

Crop Yield	Frequency	Percentage
Stable	36	18.0
Increase	28	14.0
Decrease	136	68.0
Total	200	100.0

## Discussion

The findings align with global studies (e.g., Fischer *et al.*, 2007; Kang *et al.*, 2009) [3, 9] indicating climate-induced yield reductions in rainfed systems. The observed shift in crop patterns reflects adaptive behavior, though often constrained by limited access to technology and credit. The integration of the Eco-Crop model enhances predictive capacity, supporting proactive planning.

The decline in cotton and linseed cultivation underscores the vulnerability of cash crops to climate variability. Similar trends have been reported in semi-arid regions of Jordan (Al-Bakri *et al.*, 2011) [2] and Spain (Iglesias *et al.*, 2000) [7]. The study reinforces the need for climate-resilient agricultural policies, including investment in irrigation, crop diversification, and extension services.

## Conclusion

Climate change is significantly altering agricultural systems in Nagpur District, leading to reduced yields, shifting cultivation patterns, and increased production risks. The integration of statistical analysis and modeling approaches provides robust evidence of climate-crop interactions. Without adaptive interventions, the region's food security and rural livelihoods remain at risk.

The study recommends the promotion of climate-smart agriculture, including drought-resistant crop varieties, improved water harvesting, and real-time agro-advisory services. Policymakers should prioritize district-level climate adaptation plans, supported by scientific assessments like those provided by the Eco-Crop model. Future research should explore socio-economic dimensions of adaptation and long-term modeling under different emission scenarios.

## References

1. Agrios GN. Plant Pathology. 5th ed. Elsevier, USA, 2005.
2. Al-Bakri J, Suleiman A, Abdulla F, Ayad J. Potential impact of climate change on rainfed agriculture of a semi-arid basin in Jordan. *Phys Chem Earth*,2011:36(5–6):125–34.
3. Fischer G, Tubiello FN, Velthuizen H van, Wiberg DA. Climate change impacts on irrigation water requirements: Effects of mitigation, 1990–2080. *Technol Forecast Soc Change*,2007:74(7):1083–107.
4. Gadgil S, Abrol YP, Rao, Seshagiri PR. On growth and fluctuation of Indian food grain production. *Curr Sci*,1999a:76(4):548–56.
5. Gadgil S, Rao Seshagiri PR, Sridhar PR. Modeling impact of climate variability on rainfed groundnut. *Curr Sci*,1999b:76(4):557–69.
6. Hitz S, Smith J. Estimating global impacts from climate change. *Glob Environ Change*,2004:14(3):201–18.
7. Iglesias A, Rosenzweig C, Pereira D. Agricultural impacts of climate change in Spain. *Glob Environ Change*,2000:10(1):69–80.
8. IPCC. Climate Change 2007: Synthesis Report. Geneva: IPCC, 2007.
9. Kang Y, Khan S, Ma X. Climate change impacts on crop yield, crop water productivity and food security. *Prog Nat Sci*,2009:19(12):1665–74.
10. Kumar KK, Kumar KR, Ashrit RG, Deshpande NR, Hansen JW. Climate impacts on Indian agriculture. *Int J Climatol*,2004:24(11):1375–93.

11. Ramirez JA, *et al.* Integration of FAO-EcoCrop database for climate change impact assessment: A case study on sorghum. *Agric For Meteorol*,2013:170:89–102.
12. Tubiello FN, Donatelli M, Rosenzweig C, Stockle CO. Effects of climate change and elevated CO<sub>2</sub> on cropping systems: Model predictions at two Italian locations. *Eur J Agron*,2000:13:179–89.
13. Uprety DC. Rising atmospheric carbon dioxide and crops: Indian studies. *Souvenir*, 2nd International Congress of Plant Physiology, New Delhi, 2003, 87–93.