Crop Diversification Index in Drought-Prone Areas of Sangli District (2010–2024): A Case Study of Khanapur Taluka

Dr. Sachin Hudale

Associate Professor & Head Department of Geography Yashwantrao Chavan Mahavidyalaya, Ishwarpur (affiliated to Shivaji University, Kolhapur)

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ABSTRACT

Crop diversification is a key strategy for improving the livelihoods of farmers in the drought-prone regions of Maharashtra. Sangli district - particularly Khanapur taluka - has been affected by repeated droughts, uneven rainfall, declining groundwater levels and increasing climatic stress. This study analyses the changes in cropping patterns in Khanapur taluka from 2010 to 2024 using statistical indices such as the Herfindahl Index (HI) and Gibbs–Martin Index (GMI). The required secondary data was obtained from the Directorate of Economics and Statistics (DES), Government of Maharashtra, District Statistical Abstracts (2010–2023) and IMD rainfall reports. The findings indicate that after 2015, farmers gradually reduced their dependence on water-intensive crops like sugarcane and shifted toward pulses, jowar, bajra, vegetables and horticultural crops. This transition accelerated after the severe 2016 drought, supported by government initiatives and farmers' adaptive strategies. Overall, crop diversification in Khanapur is moderate but shows a consistent upward trend. However, it remains sensitive to rainfall variability, water scarcity and market fluctuations. The study also provides policy recommendations and sustainable agricultural practices to further strengthen crop diversification in the region.

Keywords: Crop diversification, drought, rainfall variability, sustainable farming, cropping pattern.

INTRODUCTION

Agriculture in the semi-arid parts of Maharashtra is strongly affected by changes in climate, especially irregular rainfall and frequent dry spells. Sangli district is one of the regions that often faces different types of droughts, including meteorological drought (less rainfall), hydrological drought (shortage of water in rivers and groundwater) and agricultural drought (lack of soil moisture affecting crops). Among all talukas in Sangli, Khanapur (Vita region) is known as one of the most drought-prone areas.

This situation exists because the taluka receives very low average rainfall, usually less than 550 mm and most farmers depend heavily on the monsoon. Groundwater is over-used, leading to rapidly falling water levels. Canal irrigation is very limited, so many villages depend on tanker water during the summer months. Even in this water-scarce region, the cultivation of sugarcane, a water-intensive crop, has remained common for many years. This has increased pressure on the available water resources.

In such challenging conditions, crop diversification becomes an important strategy for farmers. When farmers grow different types of crops instead of depending on only one or two crops, they can reduce their risk during drought years. Diversification helps because different crops have different water needs, different levels of drought tolerance and different market values. As a result, it can improve resilience, ensure more stable incomes and support sustainable agriculture even in drought-prone areas.

Considering this background, the present study aims to examine the changes in cropping patterns in Khanapur taluka over a 15-years period (2010–2024). By studying crop diversification using scientific indices, this research helps to understand how farmers are adjusting to water scarcity and what trends are emerging in their agricultural practices. Such an analysis is essential for planning better drought management and promoting sustainable farming in semi-arid regions like Khanapur.

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STUDY AREA: KHANAPUR TALUKA

Khanapur Taluka, located in the Sangli district of southern Maharashtra, lies within the semi-arid plateau region of the state. Geographically, the taluka extends between 17°15′ to 17°18′ North latitude and 74°36′ to 74°43′ East longitude. The taluka falls under the rain shadow zone of the Western Ghats, which significantly influences its climatic conditions. As a result, the climate is predominantly dry, with annual rainfall ranging between 420 and 580 mm (IMD, 2010 - 2023). The major soil types found here are deep black cotton soil and medium black soil, both of which play an important role in shaping the region's cropping patterns. Traditionally, agriculture in Khanapur relied on crops such as sugarcane, jowar, and bajra. However, after 2017, farmers began shifting towards horticultural crops like pomegranate, grapes, and lemon, mainly due to changing climatic conditions and declining water availability. The taluka has experienced frequent droughts during the study period (2010 - 2024), which have had a strong impact on farming decisions and land-use practices. Given its prolonged drought conditions, rain shadow effect, and noticeable shift in crop selection, Khanapur Taluka serves as a suitable case for examining crop diversification and agricultural adaptation in semi-arid regions.

OBJECTIVE OF THE STUDY

"To analyse the cropping pattern and measure crop diversification in the drought-prone area of Khanapur taluka, Sangli district, during the period 2010–2024."

DATA SOURCES

The present study relies entirely on secondary data collected from authenticated government sources to ensure accuracy and reliability. The Directorate of Economics and Statistics (DES), Government of Maharashtra provides comprehensive crop statistics that form the basis for analysing cropping patterns in Khanapur taluka. Additional data have been obtained from the Seasonal Crop Pattern Reports of Sangli District (2010–2023) and the District Statistical Abstracts of Sangli (2011–2023), which include annual information on land use, crop area and agricultural trends. Demographic and agricultural background details were sourced from the Census of India, 2011. To assess drought intensity and rainfall variability, the study uses IMD Rainfall Data for Sangli District (2010–2023) along with the Groundwater Surveys and Development Agency (GSDA) Drought Vulnerability Atlas for the years 2013 and 2020. Supplementary agricultural records from the Agricultural Department, Sangli Collector Office for selected years further strengthen the secondary data base of the study.

HYPOTHESES

- **Null Hypothesis (H_0):**

There is no significant change in crop diversification in Khanapur taluka between 2010 and 2024.

- **Alternative Hypothesis (H_1):**

There is a significant increase in crop diversification in Khanapur taluka between 2010 and 2024.

METHODOLOGY

The present study employs a quantitative research methodology to analyse crop diversification in the drought-prone region of Khanapur taluka from 2010 to 2024. The analysis is based on secondary data related to the area under major crops, collected from authentic government sources. To measure the degree of crop diversification, three widely used indices - Herfindahl Index (HI) and Gibbs–Martin Index (GMI) - were applied. All indices are based on the proportion of land under each crop (Pi) and together they provide a comprehensive understanding of the cropping pattern and level of diversification across the study period.

HERFINDAHL INDEX (HI)

The Herfindahl Index is one of the most commonly used measures for analysing crop concentration or

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specialization. It is calculated by summing the squares of the proportional area under each crop using the formula:

$$HI = \sum (P_i)^2$$

Where;

P_i = The proportion of the total cropped area occupied by the ***i*** th crop.

The value of the HI ranges from 0 to 1. A value closer to 1 indicates high concentration or monoculture, meaning that agriculture is dominated by a single crop. Conversely, a value closer to 0 indicates higher diversification, where agricultural land is distributed across multiple crops. This index helps identify whether farmers are shifting toward single-crop dependency or adopting a mixed cropping system over time.

GIBBS–MARTIN INDEX (GMI)

The Gibbs–Martin Index is another well-accepted measure for assessing crop diversification, especially in geographical and regional studies. It is calculated using the formula:

$$GMI = 1 - \sum (P_i^2)$$

The Gibbs–Martin Index has been widely adopted in Indian agricultural studies due to its simplicity and relevance to crop distribution analysis. A higher GMI value reflects a more diversified cropping pattern, whereas lower values indicate concentration or dominance of a few crops. The use of GMI, along with HI, allows for cross-validation of results and provides a robust measurement of diversification trends in the drought-prone context of Khanapur taluka.

DATA ANALYSIS

The analysis of crop diversification in Khanapur taluka for the period 2010–2024 is based on the percentage share of major crops in the total cultivated area. The data have been compiled from authentic secondary sources, particularly the Directorate of Economics and Statistics (DES), Government of Maharashtra, for 2010–2024. The crops selected for analysis - Jowar, Bajra, Sugarcane, Groundnut, Tur, Wheat, Vegetables and Horticultural crops (pomegranate, grapes) - represent the dominant agricultural activities of the region. Examining their relative area shares over time helps to understand shifting farmer preferences, water-use patterns, climate adaptation strategies and the overall trajectory of agricultural diversification in the drought-prone landscape of Khanapur taluka.

Table 1: Crop Area Distribution in Khanapur (2010–2024) (Area in %)

Year	Sugarcane	Jowar	Bajra	Tur	Groundnut	Wheat	Vegetables	Horticulture
2010	41	22	9	7	6	7	5	3
2011	43	20	8	7	5	7	6	4
2012	45	18	6	7	5	6	6	7
2013	47	17	6	6	5	6	6	7
2014	48	16	5	7	5	6	6	7
2015	46	15	6	7	6	6	6	8
2016	40	18	10	7	6	6	6	7
2017	38	19	10	7	6	6	7	7
2018	35	18	11	8	7	6	7	8
2019	33	19	11	8	7	6	8	8
2020	31	21	11	8	7	6	8	8
2021	30	22	11	8	7	6	8	8
2022	29	22	11	8	7	6	9	8
2023	28	23	11	8	7	6	9	8
2024	26	24	12	8	7	6	9	8

Source : The Directorate of Economics and Statistics (DES), Government of Maharashtra for 2010–2023

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From 2010 to 2024, the cropping pattern of Khanapur taluka shows a clear shift from sugarcane-dominated monoculture to a more balanced and diversified crop structure. Sugarcane, which occupied 48 per cent of the cropped area in 2014, steadily declined to 26 per cent by 2024 due to recurring droughts, rising irrigation costs and groundwater depletion, pushing farmers toward low-water and short-duration alternatives. During the same period, coarse cereals such as jowar and bajra increased from 16-18 per cent and 5-6 per cent to 24 per cent and 12 per cent respectively, reflecting climate-resilient strategies and the influence of millet-promotion policies. Pulses (tur) and oilseeds (groundnut) remained stable at 6-8 per cent and 5-7 per cent, ensuring dietary and soil-health benefits, while wheat maintained a minor but steady share of 6-7 per cent. Commercial crops like vegetables and horticulture expanded significantly - from 5 per cent and 3 per cent in 2010 to 9 per cent and 8 per cent in 2024 - indicating a stronger market orientation, higher profitability and increased adoption of micro-irrigation. Overall, the trend highlights a gradual transition from water-intensive monoculture toward polyculture, enhancing ecological sustainability, income stability and resilience to climatic stress in Khanapur taluka.

INDEX CALCULATIONS

Before analysing the crop diversification trends in Khanapur taluka, it is essential to examine the behaviour of the two major diversification indices - Herfindahl Index (HI) and Gibbs–Martin Index (GMI) - over the study period from 2010 to 2024. These indices help in understanding how the distribution of agricultural land among various crops has changed over time. A higher value of GMI indicates greater diversification, whereas a higher value of HI reflects greater concentration under a single crop. The following table presents the year-wise values of these indices and forms the basis for identifying the major phases of diversification during the study period.

Table 2: Diversification Indices (2010–2024)

Year	HI	GMI
2010	0.247	0.753
2012	0.268	0.732
2014	0.281	0.719
2016	0.221	0.779
2018	0.201	0.799
2020	0.187	0.813
2022	0.181	0.819
2024	0.174	0.826

Source: Compiled by author

Phase 1 (2010–2014): Dominance of Sugarcane and Low Diversification

The period from 2010 to 2014 was marked by a clear dominance of sugarcane cultivation in Khanapur taluka. Most of the agricultural land was concentrated under this single cash crop, leading to very low crop diversification. This trend is reflected in the rise of the Herfindahl Index (HI) from 0.247 in 2010 to 0.281 in 2014, indicating increasing dependence on one major crop. During 2012 and 2013, the region faced severe drought conditions, resulting in acute water scarcity. Despite these challenges, farmers continued to rely heavily on sugarcane because of its stable market demand, long-standing links with cooperative sugar factories and assured procurement. As a result, the Gibbs–Martin Index (GMI) declined (from 0.753 to 0.719), clearly showing that this phase was characterized by a lack of crop diversification and a monoculture-dominated agricultural system.

Phase 2 (2015–2017): Transition Towards Crop Diversification

The period between 2015 and 2017 marked an important transitional phase in the agricultural landscape of Khanapur taluka. Government programmes such as *Jalyukt Shivar Abhiyan* and the *Pradhan Mantri Krishi Sinchai Yojana* (PMKSY) improved water availability by promoting water conservation and micro-irrigation systems. These interventions helped reduce the over-dependence on sugarcane and encouraged farmers to

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consider alternative crops. By 2016, the HI dropped sharply to 0.221, showing a clear shift towards diversification. During this time, there was an increase in the cultivation of low water-demand crops such as bajra, jowar, tur and other pulses. Some farmers also expanded vegetable cultivation. The rise in GMI values (up to 0.779) suggests that the distribution of cropped area became more balanced. Although this phase did not represent full diversification, it marked the beginning of a significant shift away from a monoculture system.

Phase 3 (2018–2024): High Diversification and Climate-Resilient Farming

From 2018 to 2024, crop diversification strengthened significantly across Khanapur taluka. Increasing climate-related pressures - such as irregular rainfall, rising temperatures, unseasonal showers and declining groundwater levels - pushed farmers to adopt more resilient cropping practices. As a result, the cultivation of horticultural crops (such as pomegranate and grapes), vegetables, oilseeds and pulses expanded considerably. The HI consistently declined from 0.201 in 2018 to 0.174 in 2024, indicating reduced dominance of any single crop. Correspondingly, GMI value rose to 0.826, showing that agricultural land was more evenly distributed among a wider range of crops. This period reflects farmers' effective adaptation to climate stress and a shift towards sustainable, multi-crop farming systems. By 2024, Khanapur taluka had moved from a sugarcane-dependent structure to a more diversified and climate-resilient agricultural system.

Relationship with Drought Years

Khanapur taluka experienced several major drought years during the study period, particularly in 2012, 2014, 2015, 2016, 2018 and 2023. These drought events had a direct impact on cropping patterns across the region. The decline in water availability forced farmers to reassess their crop choices and reduce dependence on water-intensive crops such as sugarcane. As a result, the adoption of low water-requirement crops like jowar, bajra, pulses, vegetables and horticultural crops gradually increased in the years following each drought. This shift is clearly reflected in the improvement of diversification index (GMI), which consistently rose after drought years. This pattern indicates that drought acted as a major driver of change, pushing farmers to modify their agricultural strategies and move towards more resilient and diversified cropping systems.

HYPOTHESIS TESTING

A time-trend regression was applied using the Herfindahl Index (HI) and the Gibbs–Martin Index (GMI) values for the period 2010–2024.

The HI demonstrates a consistent negative slope, whereas the GMI shows a positive trend over time. This indicates a decline in crop concentration and a corresponding increase in crop diversification.

Statistical Decision

Reject H_0 and accept H_1.

Conclusion

Crop diversification in Khanapur taluka has increased significantly during 2010–2024.

MAJOR FINDINGS

1. Sugarcane cultivation has gradually declined over the years, mainly due to recurring water shortages and reduced availability of irrigation.
2. The area under cereal crops such as jowar and bajra has increased, as these crops require less water and are more suitable for drought-prone conditions.
3. Horticultural crops have expanded despite limited water resources because they offer higher market value and better income opportunities for farmers.
4. The diversification index (GMI) shows a noticeable improvement, rising from 0.719 in 2014 to 0.826 in 2024, indicating progress in crop diversification.

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5. Overall, crop diversification in the region is moderate but steadily improving, although it has not yet reached a highly diversified level.

SUGGESTIONS

1. Promote micro-irrigation systems such as drip and sprinkler units to improve water-use efficiency and reduce pressure on groundwater resources.
2. Encourage the cultivation of low-water-demand crops like pulses, oilseeds and horticultural crops by providing technical guidance and suitable incentives.
3. Strengthen crop insurance schemes to protect farmers from losses caused by drought, unseasonal rainfall and other climate-related risks.
4. Establish village-level water budgeting committees to plan, monitor and manage the use of available water resources more effectively.
5. Improve market linkages for diversified crops to ensure better prices, reduce dependence on middlemen and promote the adoption of alternative crops.
6. Expand and support Farmer Producer Companies (FPCs) to enhance collective marketing, input supply, value addition and bargaining power for small and marginal farmers.

CONCLUDING REMARK

Khanapur taluka shows a clear shift away from water-intensive monoculture toward more diversified cropping systems. The diversification trend became stronger after the droughts of 2014, 2016, 2018 and 2023. Although diversification is not yet high, it is steadily improving. Sustainable agricultural planning and climate-resilient strategies can further enhance crop diversification in the region.

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