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Diversification Trends in Kharif Cropping: A Geoinformatics Study of Hisar District Over the Last Decade (2015-25)

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Abstract

Agricultural diversification is crucial for enhancing resilience, ensuring food security and promoting sustainable land management [1]. The rising population, declining land-to-man ratio, small and fragmented landholdings are putting extreme pressure on land and water resources. Rice which is mostly grown in flooded or submerged conditions in kharif season has further intensified the stress on the district's freshwater resources [2,5]. The present study investigates the diversification trends in kharif cropping patterns within Hisar District, Haryana over the last decade (2015 to 2024). The study is conducted based on the high-resolution satellite data using digital image classification techniques in GIS software and secondary database acquired from the Statistical Abstract of Haryana for the year 2015 and 2024 and published statistics by the Department of Economic and Statistical Affairs, Haryana. The main objective of the study to analysis the shifting of kharif cropping pattern in specific crops like cotton and rice. Our findings reveal significant changes in the dominance of traditional crops and the emergence of new cultivation practices. Factors influencing these trends, including climate variability, market dynamics and government policies are discussed. The results highlights that despite several challenge including soil salinity, extreme temperature stress, moderate soil fertility, and frequent pest infestations the area under rice cultivation has been expanding each year [3]. This shift has led to multiple environmental consequences such as increased reactive nitrogen emissions due to excessive use of nitrogen - based fertilizers like urea, ammonia volatilization resulting from the decomposition of urea-based fertilizers in flooded rice fields, greenhouse gas emissions and water pollution. Additionally, the shift carries significant socio-economic implications for the region.

Keywords: Kharif Cropping Pattern, Supervised Classification, Rice cultivation, High resolution satellite data.

INTRODUCTION

Agriculture has been the most practiced economic activity since ancient times, feeding millions of families and continuing as the leading primary activity in India [4,9]. It plays an important role in the rural economy and provides a source of livelihood for local communities. Hisar, the second-largest district of Haryana, has an area of 3,983 square kilometers. As per the 2011 Census, 70.8% of Hisar's population depends on agriculture for their livelihood [10]. They practice agriculture, growing crops to support their families and

earn their living. Often, two crops are cultivated every year. The main kharif crops grown during this period are Rice, Bajra, Cotton and Sugarcane while Rabi crops are Wheat, Barley, Mustard and Gram [12]. The main aim of the present study is to evaluate the kharif cropping pattern for the year 2015 and 2024 and to assess the kharif crop diversification during the last decade in the study area.

Study Area

Hisar, the second largest district in Haryana, located at 28°53'45" to 29°49'15" North latitude and 75°13'15" to 76°18'15" East longitude. Having area of 3,983 square kilometers, surrounded by Fatehabad and Jind districts of Haryana in north east and north respectively [10,14]. Eastern side shares boundary with Rohtak district while southern side share boundary with Bhiwani district of Haryana [13]. Western side of the district shares boundary with Hanumangarh district of Rajasthan State.

Hisar experiences a predominantly arid climate with significant temperature variations, ranging from average highs of 43°C in May and June to lows of 5°C in January. The district receives an annual rainfall of approximately 330 mm, primarily during the southwest monsoon season from late June to mid-September. The fertile plains of Hisar are favorable for cultivating a variety of crops. Major Kharif crops include Rice, Jowar (sorghum), Bajra (pearl millet), Maize, Cotton, Sugarcane and Groundnut [7]. The district's agriculture has evolved from traditional practices to more diversified cropping patterns, influenced by factors such as climate, soil conditions and irrigation availability [6]. Location map of the study area is displayed in Figure-1.

Database and Methodology:

Database and software used:

The present study is based on secondary database. Landsat-8, Landsat-9 and Sentinel -2 is used for the preparation of kharif cropping pattern. Statistical Abstract of Haryana for the year 2015– and 2024 was used for the present study and collected from official government websites of State Statistical published by Department of Economic and Statistical Affairs, Govt. of Haryana. Similarly, climatic was collected from Meteorological Department, CCS HAU. Hisar. Methodology flow chart (Figure-2) discussed about the details of methodology used in the present study. Details of satellite data with their specification used in the study is discussed in Table 1.

Table 1 Details of satellite data

Data Type	Spatial Resolution	Date of satellite passing	Source
Landsat-8	30 Meter	22-08-2024	https://earthexplorer.usgs.gov/
Landsat-9	30 Meter	21-08-2024	https://earthexplorer.usgs.gov/
Sentinel 2	10 Meter	21-08-2024	https://www.sentinel-hub.com/
Landsat-8	30 Meter	30-08-20215 & 06-09-2015	https://earthexplorer.usgs.gov/

Software used:

ERDAS imagine 9.3 software is used for the preparation of the NDVI (Normalized Difference Vegetation Index), ArcGIS Desktop 10.3 is used for vectorization, geometrical calculations and map making and MS office 2014 used for various statistical analysis and report writing.

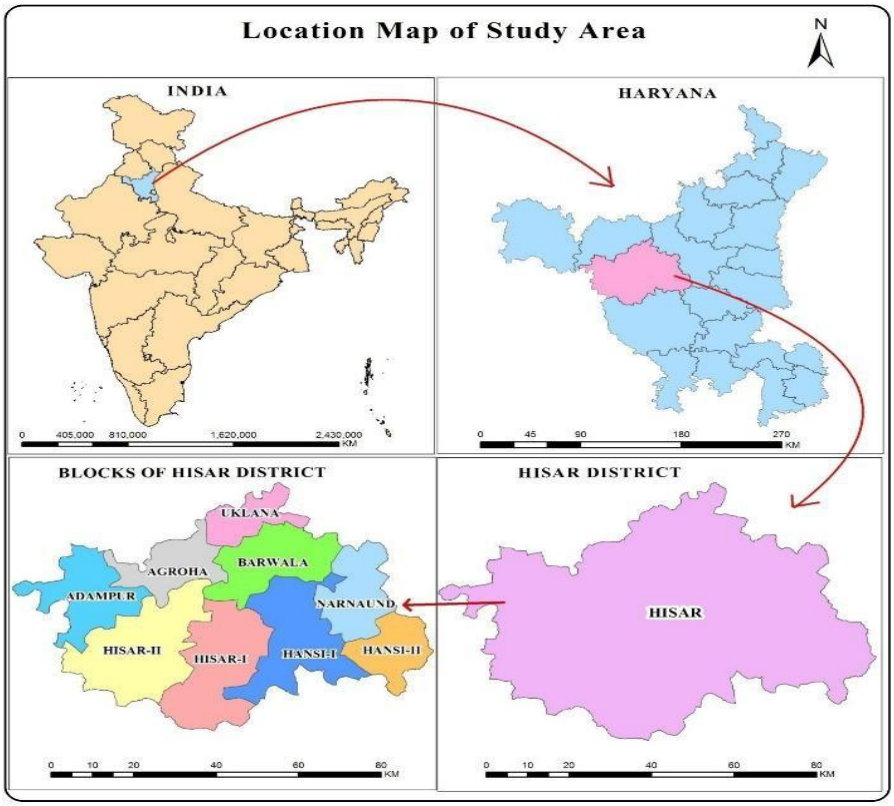

Figure-1

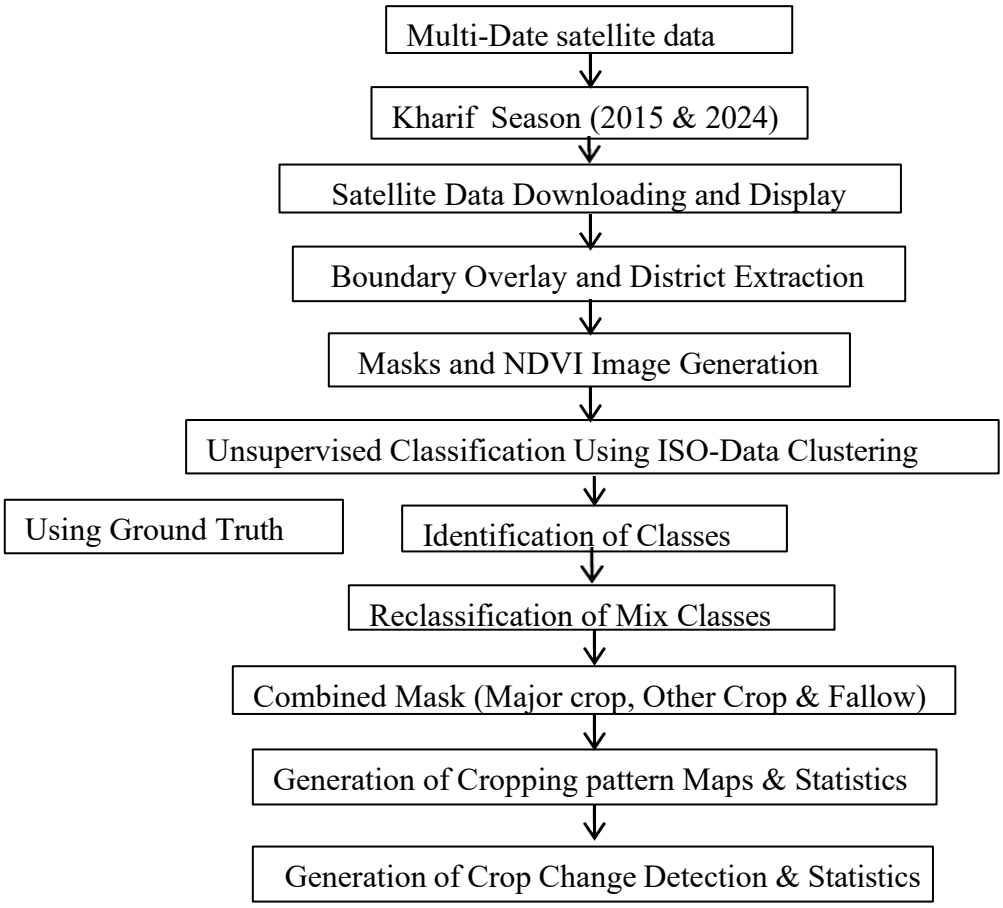

Figure 2. Methodology Flow Chart

Results & Discussion

Monitoring of Kharif Cropping Pattern (2015 to 2024)

The Kharif cropping pattern in the study area is intrinsically linked to the monsoon season which typically spans from June to September [8,11]. This period is characterized by high temperatures and abundant rainfall, creating ideal conditions for crops that require significant moisture. The Figure 3 represents kharif cropping pattern for the year 2015 and four major crops were observed i.e. cotton and rice are the predominant crops in the region, followed by bajra and sugarcane. Cotton was the dominant crop in the study area covering a significant portion particularly in the central and western regions that is cultivated in 117.17 '000 Hectares area (Table-2) and in 2024 it is also observed that cotton is also dominant crop with 185.41 '000 Hectares area (Table-2). Rice cultivation was dispersed across the district during the year 2015 but it was primarily concentrated in the northern and eastern regions nearly 76.71 '000 Hectares area and increased to 136.51 '000 Hectares area during the period 2015 to 2024. Since rice is a water-intensive crop, it is predominantly cultivated in areas with relatively better irrigation infrastructure. Bajra, also known as pearl millet, is cultivated in smaller patches, primarily in the southern and southwestern areas having 24.41'000 Hectares area and it is observed that Bajra crop is decreased to 1.06 '000 Hectares area during the last decade. As a drought-resistant crop, bajra is grown in regions with limited irrigation facilities. On the other hand, sugarcane is being cultivated only in well irrigated pockets of the district. Figure 2 highlights that yellow color represents fallow land, indicating that areas in left part of the study area was uncultivated during the kharif season in 2015. The orange color represents non-cropped areas, including settlements, industrial zones, roads and barren lands. These areas are primarily concentrated in the central (representing the urban center, Hisar city) and southern parts of the district (Figure 2 and Figure 3).

Table-2 Aerial extension of Kharif Cropping pattern during 2015 and 2024

Crop	**2015**	**2024**	**Changes**
	Area in '000 Hectares	Area in '000 Hectares	**(2015 - 2024)**
Sugarcane	0.02	0.07	0.05
Cotton	177.17	185.41	8.24
Bajra	24.41	1.06	-23.35
Rice	76.71	136.51	59.8
Fallow Land	68.54	23.84	-44.7

Assessment of Crop diversification during the period 2015 to 2024

Changes in cropping patterns are a dynamic aspect of agriculture, influenced by a complex interplay of factors. The adoption of high-yielding varieties (HYVs) of crops like rice spurred by the Green Revolution, has led to a concentration on these crops in many parts of the study area in 2024. There is also a noticeable trend towards cultivating cash crops like cotton, sugarcane driven by market demands and potential for higher incomes. Analyzing both the maps (Figure 3 and Figure 4) and Table 3 (pivot table) represents the spatial patterns and inter crop shifting trends during the last decade. It is observed that 2.21 sq. km area of cotton crop is replaced to bajra,
643.24 sq. km area is replaced with rice and 0.28 sq. km. area is replaced with sugarcane while
842.10 sq. km area remain unchanged during the period of last decade. Similarly, 314.81 sq. km area of rice crop is replaced with cotton, 0.19 sq. km. area is replaced with bajra crop and 635.91 sq. km area still

remain unchanged during the period 2015 to 2024. Figure-4 shows that a considerable change is observed in eastern region of Hisar (near Barwala and Uklana) of cotton fields into rice. he central part of the district also experienced Fallow lands being converted into Rice fields. This shift is likely due to improved canal irrigation, better access to groundwater, favourable government policies and MSP. The northwestern region (Narnaund and Adampur) has experienced an increase in cotton cultivation over the last decade. However, Cotton has been replaced in some areas, particularly in the eastern and central belt as cotton to rice. The central and western regions of Hisar have seen more land being left fallow, due to water scarcity in non-canal areas.

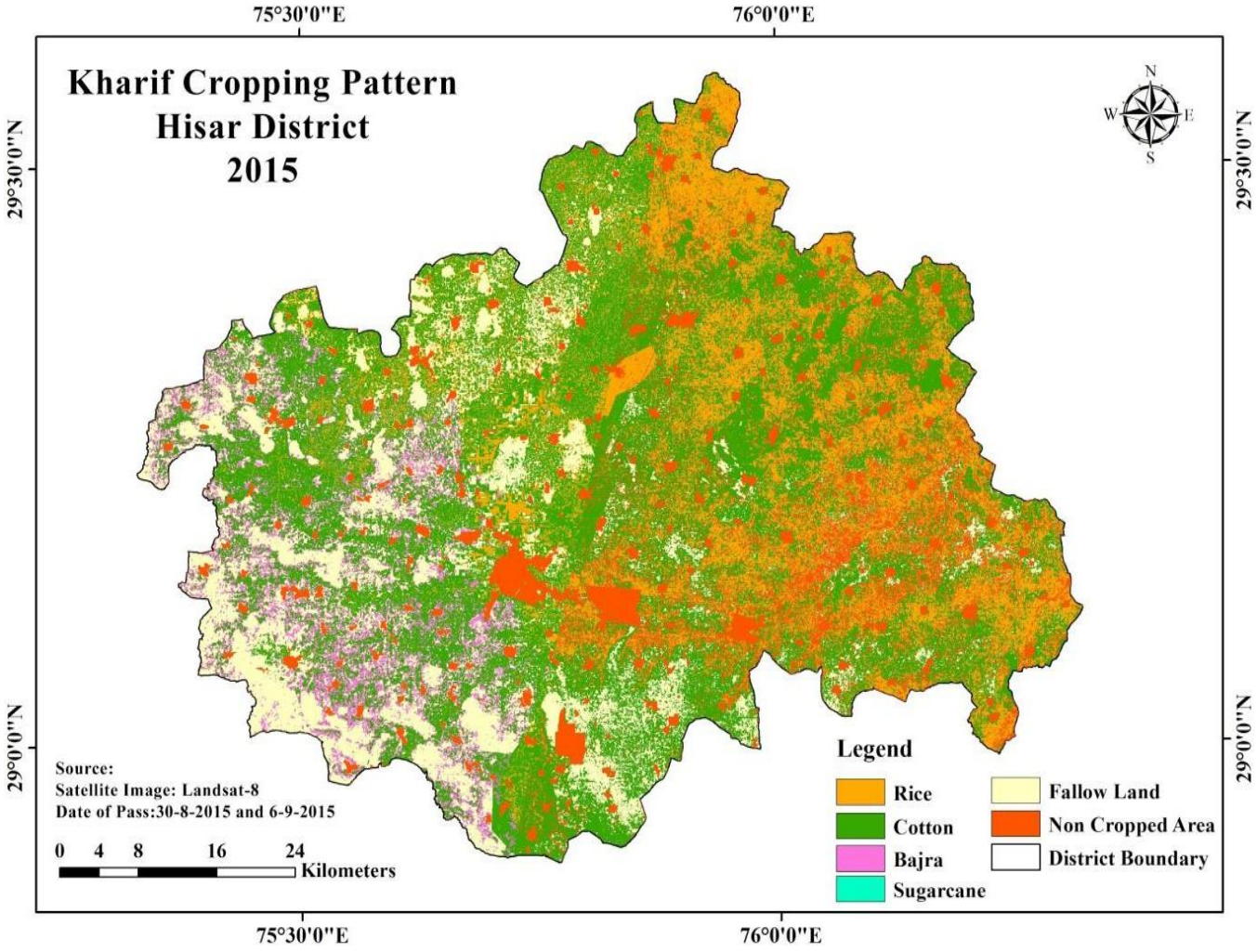

Figure -3

Table 3 Analysis of inter crop changes during the period 2015 to 2024 (Area in hectare)

2024 / 2015	Cotton	Bajra	Rice	Fallow Land	Sugarcane	Total
Cotton	842.10	2.21	643.24	76.09	0.28	1563.91
Bajra	193.58	13.07	19.00	18.64	0.00	244.29
Rice	314.81	0.19	635.91	12.64	0.24	963.79
Fallow Land	444.50	5.51	89.72	156.60	0.03	696.36
Sugarcane	0.08	0.00	0.16	0.12	0.00	0.37
Total	1795.08	20.97	1388.04	264.08	0.55	3468.71

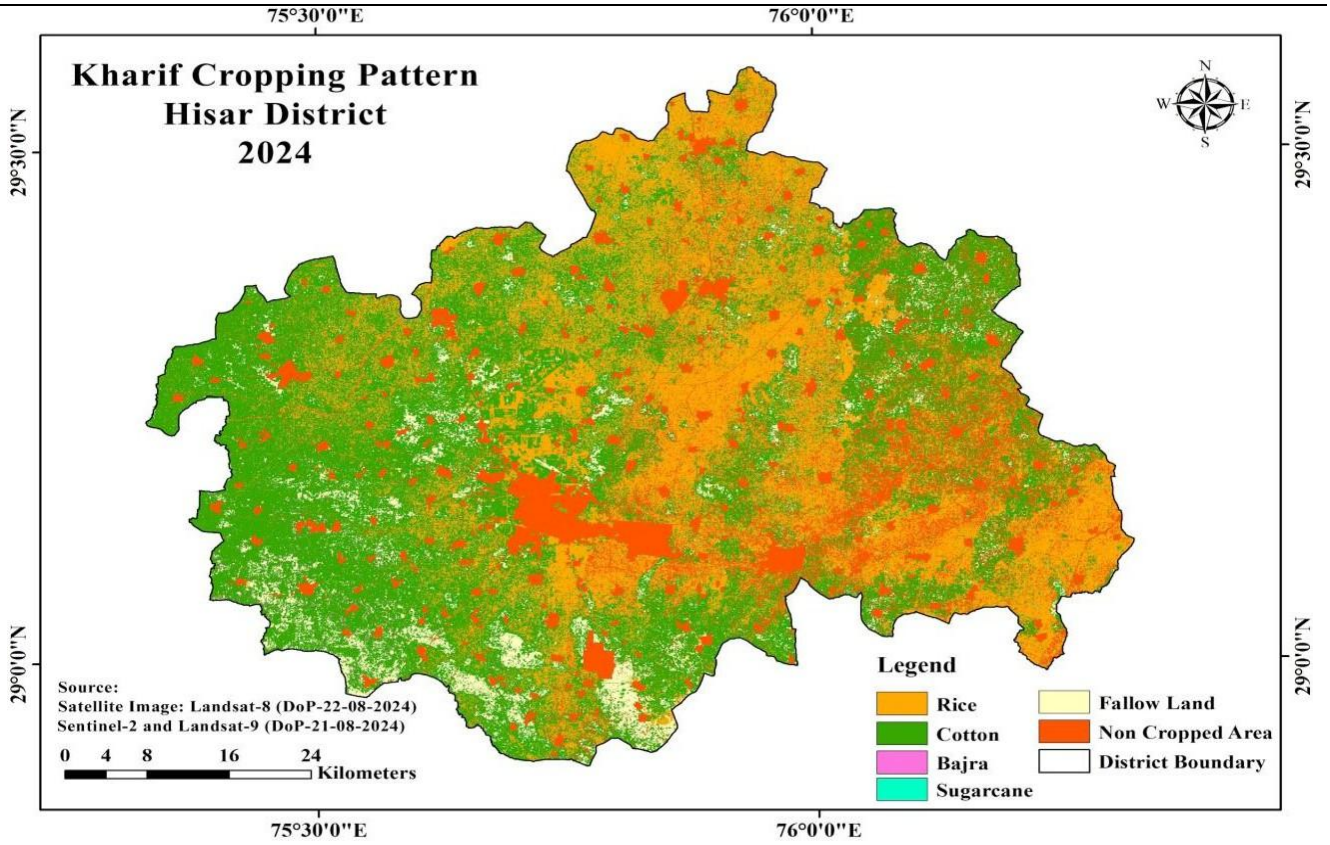

Figure 4

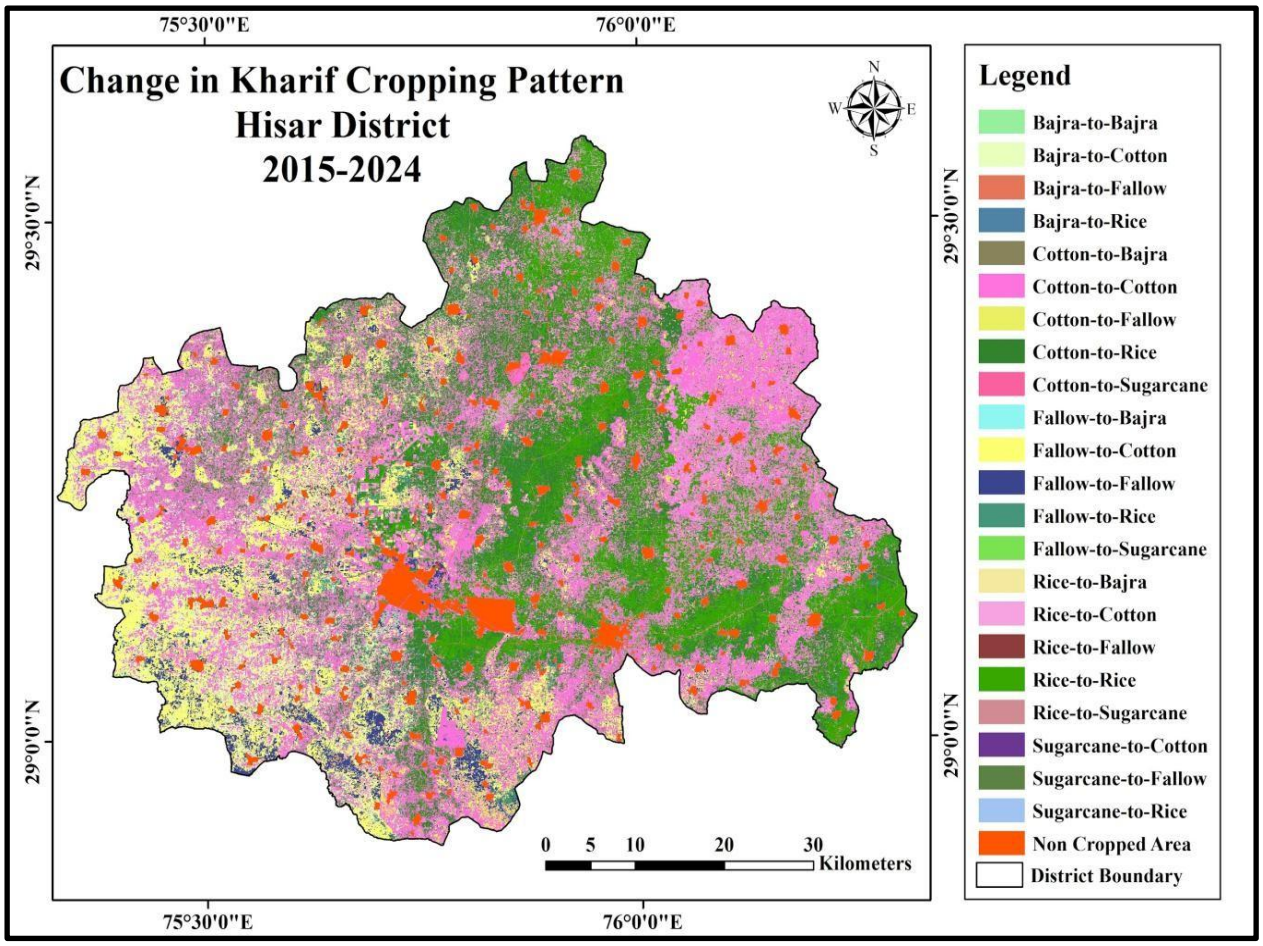

Figure 5

Over the last decade, there have been sudden changes in the cropping pattern in this district. Before 2015, farmers cultivated Bajra, Cotton, Guar and other crops usually associated with the semi-arid climatic conditions of the area. However, due to various physical, economic, and social factors, farmers have shifted towards cultivating water-intensive crops, primarily rice, followed by Cotton. Changing climatic conditions, such as unpredictable and irregular rainfall, have disrupted sowing and harvesting schedules, leading to reduced crop yields. Additionally, extreme weather events, such as dry spells and heatwaves, pose significant risks to crop health and farmer profitability.

Conclusion

The present study provides a comprehensive geoinformatics-based assessment of kharif cropping diversification in Hisar District over the last decade (2015–2024). The analysis of multi-date satellite imagery, supported by secondary statistical data, clearly indicates a significant shift in the district's cropping structure, driven largely by the expansion of rice cultivation at the expense of traditionally dominant crops such as bajra and fallow land. Although cotton continues to be a major kharif crop, the most notable change is the 59.8 thousand hectare increase in rice area**,** despite the region's semi-arid climatic conditions and limited natural water availability.

These changes reflect the combined influence of improved irrigation infrastructure, government incentives, MSP assurance, and farmers' pursuit of economic stability. However, the increasing preference for water-intensive rice cultivation in an ecologically fragile and water-scarce region raises serious environmental concerns. The study identifies multiple consequences, including groundwater depletion, soil salinity, nitrogen-based fertilizer emissions, ammonia volatilization in rice fields, and a decline in biodiversity. The reduction of bajra—an inherently drought-resistant and climate-appropriate crop—further highlights the growing imbalance between agricultural practices and environmental sustainability. The decade-long change detection matrix confirms large-scale conversions of cotton and fallow land into rice fields, especially in the eastern and central parts of the district. While diversification has improved short-term livelihood opportunities, it has simultaneously increased ecological vulnerability. Therefore, there is an urgent need for policy interventions, promoting climate-resilient crops, regulated groundwater extraction, crop rotation, and sustainable soil-water management practices. The study demonstrates the power of satellite-based geospatial techniques in monitoring cropping dynamics and provides valuable insights for planners, policymakers, and the agricultural community of Hisar District.

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