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Spatio-Temporal Analysis of Land Use Land Cover Change: A Case Study of Nagpur Division of Vidarbha Region

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Abstract :

The study looks at how the land cover has changed over the past 20 years, from 2000 to 2020, and how it has affected agriculture in the Central India's Nagpur Division of Vidarbha region. Data on land use and land cover (LULC) were gathered from USGS Earth Explorer for three distinct time periods starting in 2000, 2010, and 2020. Five categories of land use and land cover mapping were selected and employed in this study, which includes digital interpretations and screen digitization of satellite image data (Landsat 5, 7 (TM) and Landsat 8 (OLI/TIRS) from 2000 to 2022). After ground verification and accuracy evaluation, final land use and land cover maps were created utilising remote sensing and geographic information systems. The main problem that may influence environmental change was the reduction of agricultural land. Variations in land usage and land cover might have an impact on the local community's quality of life and the environment; in particular, the issue of land degradation requires immediate attention.

Keywords : LULC, Vidarbha Region, Agriculture, Local Community, Quality of Life.

Introduction :

Agriculture plays a vital role in global food security, economic growth, and sustainable development. Understanding the trends and dynamics of agriculture at various scales, from global to regional levels, is essential for policymakers, researchers, and stakeholders to formulate effective strategies and interventions (Bassi et al., 2014). It has a critical role in the global economy, livelihoods of millions of people, and overall food security (Chattopadhyay et al., 2018). Understanding the significance of agriculture in different contexts helps policymakers, researchers, and stakeholders formulate strategies to support sustainable agricultural practices, rural development, and economic growth (Deshmukh et al., 2021). Global trends in agriculture, considering factors such as population growth, changing dietary patterns, technological advancements and environmental concerns. It will explore the shift from traditional farming practices to modern agricultural systems, including the adoption of precision agriculture, sustainable intensification, and organic farming (Kadam et al., 2019). Agriculture products and associated services are the primary source of food production globally; ensures an adequate supply of food to meet the nutritional needs of the growing population (Gaurav et al., 2008). Sustainable agricultural practices, technological advancements, and improved access to markets contribute to global food security (Farkhade, 2014). Agriculture is a significant contributor to the global economy. It provides employment opportunities, generates income for rural communities, and contributes to Gross Domestic Products (GDP) growth. The agricultural sector also stimulates related industries such as food processing, agribusiness, and rural infrastructure development. Agriculture services have the potential to lift people out of poverty, particularly in developing countries. Small-scale farmers rely on agriculture for their livelihoods, and improving agricultural productivity and market access can enhance their income and overall well-being (Deokate et al., 2022).

Additionally, global trade patterns, agricultural productivity, and the impact of climate change on agricultural production. This research article delves into the trends specific to Maharashtra, analyzing factors such as cropping patterns, irrigation systems, agricultural productivity, and the role of horticulture and cash crops (Gajbhiye

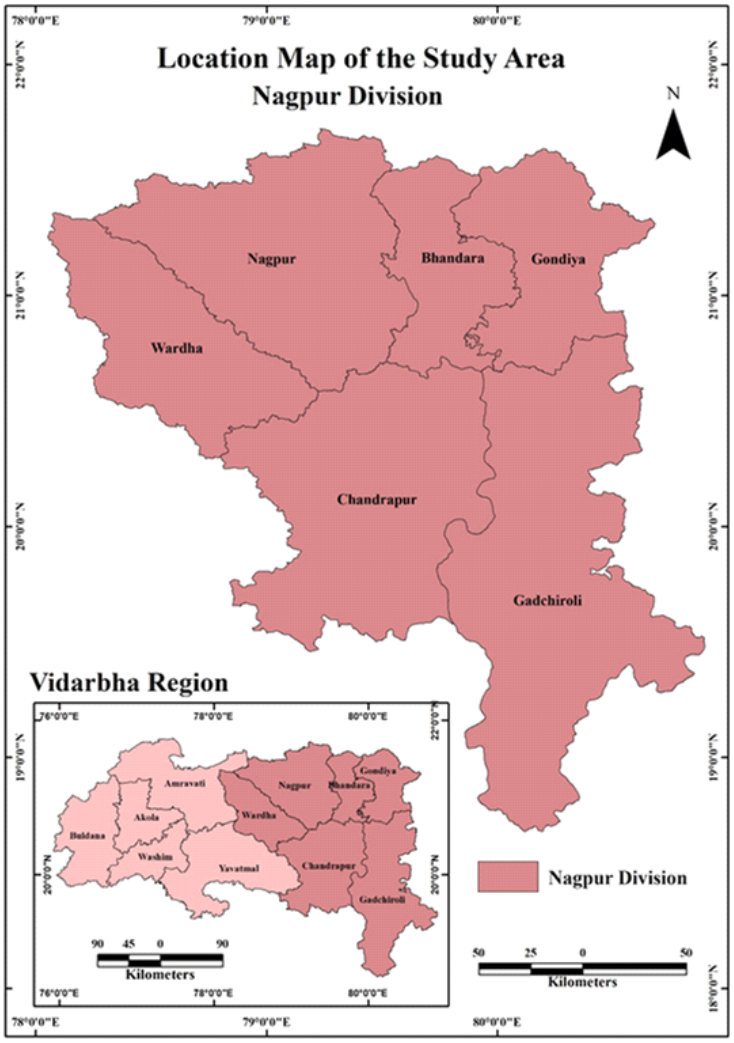
et al., 2008). It will also assess the challenges faced by the state, including water scarcity, land fragmentation, and climate variability, and explore initiatives for sustainable agriculture. The Vidarbha region in Maharashtra holds specific significance due to its agricultural prominence and unique challenges. This section will focus on the trends of agriculture in Vidarbha, including the dominance of cotton cultivation, crop diversification efforts, watershed management practices, and the impact of government policies on farmer welfare. The article will address the socio-economic aspects of agriculture in the region, such as rural poverty, farmer distress, and the role of agricultural cooperatives.

India is one of the world's largest producers of staple crops such as rice, wheat, and pulses. Agriculture ensures food security for its vast population and helps stabilize food prices through domestic production. Agriculture is a primary source of livelihood for a significant proportion of the Indian population, particularly in rural areas (Joshi & Lepse, 2017). Small-scale farmers, landless laborers, and rural communities depend on agriculture for income generation and employment opportunities. India, with its vast population and diverse agro-climatic regions, holds a significant position in global agriculture. Indian agriculture, including shifts in cropping patterns, changes in land use, adoption of agricultural technologies, government policies and the role of small-scale farmers. The agricultural sector contributes significantly to India's economy (Ghatol & Karale, 2000). It accounts for a substantial share of GDP and provides a livelihood for a large number of people. Additionally, the sector stimulates rural development, agro-based industries, and export earnings. Maharashtra, one of India's leading agricultural states, has a diverse agro-climatic region, allowing for a wide range of agricultural activities. The state produces various crops, including fruits, vegetables, cereals, and cash crops. This diversity contributes to the state's agricultural resilience and income generation. Agriculture in Maharashtra provides employment opportunities for a significant portion of the population. Farmers, farm laborers, and agribusinesses contribute to rural employment and livelihoods. Agriculture plays a crucial role in rural development, poverty reduction, and improving the standard of living (Singh & Kumar, 2014). Initiatives such as watershed management, agricultural cooperatives, and technological interventions have contributed to sustainable agriculture and rural prosperity.

The spatio-temporal analysis of land use, land cover, and agriculture plays a vital role in understanding the dynamic changes occurring in a region and their implications on various socio-economic and environmental aspects (Lokhare et al., 2013). In the context of the Nagpur Division in the Vidarbha region, this analysis becomes particularly significant due to the region's agricultural prominence and the evolving land use patterns. This analysis aims to investigate the changes in land use and land cover patterns, particularly in relation to agriculture, over a specified period. By utilizing satellite imagery, remote sensing techniques, and Geographic Information Systems (GIS), researchers can examine the spatial distribution, temporal trends, and interdependencies among various land use categories, such as croplands, forests, settlements, water bodies, and other relevant features.

Study Area :

Vidarbha is the name of the eastern most part of the Maharashtra State. Two classical Sanskrit epics that make mention of this area are the Ramayana and the Mahabharata (Gaurav, 2015). East Vidarbha is the name given to the region of Vidarbha that faces east. The Nagpur division is the name of the state of Maharashtra's administrative division. Vidarbha was a region of Madhya Pradesh known as the Berar while it was governed by the British (Joshi & Lepse, 2017). When Madhya Pradesh was reorganised in 1956, the Marathi-speaking component of the state was split off and included into the Bombay State, which has been a part of Maharashtra since Maharashtra's separation in 1960, this region is known as Vidarbha. East Vidarbha is located in the eastern part of Maharashtra State, in the centre of the Indian subcontinent. Between the latitudes of 18° 43'N and 21° 40'N and the longitudes of 78° 2'E and 80° 59'E, it reaches below the Tropic of Cancer (Kadam et al., 2019). It extends in both the west and east, from Salekasa tahsil in the Gondia district to Deoli tahsil in the Ardhthe district. Its north-south extent is much broader from Ramtek in the Nagpur district to Siron Tahsil in the Gadchiroli district. The Arabian Sea is 595 km from its western boundary. Its southern most point is around 300 km from the Bay of Bengal. East Vidarbha has a maximum north-south breadth of 325 km and an east-west extension of 272 km. East Vidarbha is divided into six districts: Chandrapur, Nagpur, Bhandara, Gondia, and Wardha.



Source: Prepared by Research Scholar, 2022.

Figure 1 : Location Map of Nagpur Division of Vidarbha Region

Research Methodology :

In order to assess the land use and land cover of the Vidarbha region's Nagpur division, this study used the LULC approach. The satellite images of the years 2000, 2010, and 2020 were collected via the USGS Earth Explorer Portal using two separate Landsat series satellites, Landsat 5 and 7 TM and Landsat 8 OLI/TIRS (Table 1). Pre- and post-monsoon season 146/38 (Path/Rows) adherent satellite

pictures have been downloaded with less than 10% cloud cover. To calculate the LULC from 2000 to 2020, the Erdas Imagine 14.0 employed a hybrid technique that blends supervised and unsupervised classification (Mani & Varghese, 2018). Satellite image classification has been finished using supervised classification and a maximum likelihood classifier.

By digitising a specific area (ROI) on the image, it is able to choose different signatures of different characteristics (training sites) (Kumar et al., 2018). Field expertise, published works, and official maps were used to choose the signatures. In order to as certain the precise value of the collected pixels, the "I tool" has been used to calculate the values of each pixel for each of the twelve categories. The pixel

Table 1 : Acquisition of Landsat Satellite Images for Nagpur Division

Sl No.	Satellite	Year	Path/Row	Date
1	Landsat 7 TM	2000	144/045 144/045 144/045	29-02-2020 25-03-2000 17-04-2000 26-05-2000
2	Landsat 5 TM	2010	145/045 145/046	31-01-2010 21-04-2010 16-05-2010 30-05-2010
3	Landsat 8 OLI/TIRS	2020	146/045 146/046	16-04-2020 18-05-2020 25-05-2020 27-05-2020

Source: USGS, Earth Explorer, 2020. Designed by Research Scholar, 2022.

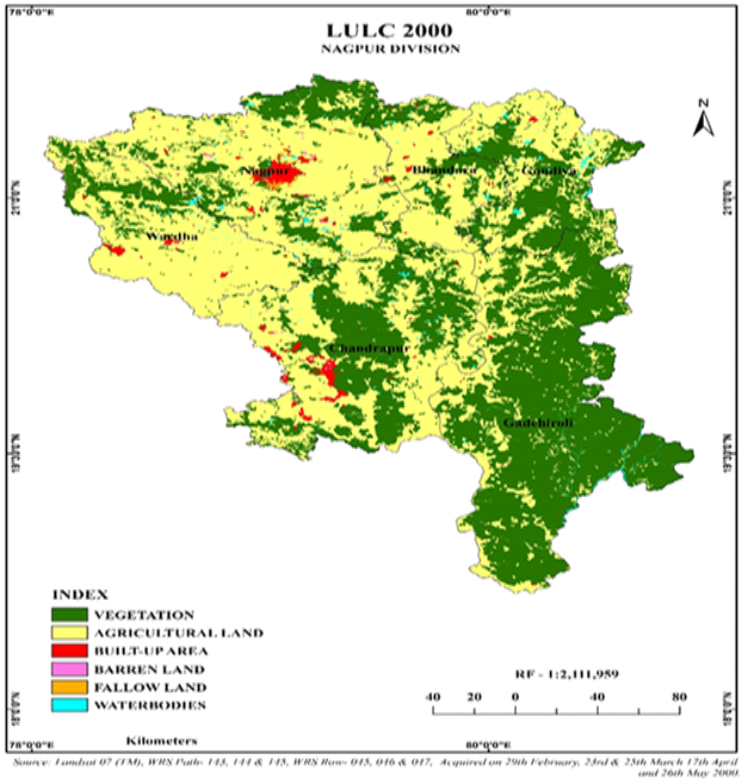
values for each group were then compared with the unique satellite imageries for various years in order to identify the different forms of land use (Nair & Mirajkar, 2021). For the targeted division, the types of diverse land use cover have been identified if the obtained satellite photos confirmed that the pixel values indicated an open or reasonably dense forest (Maurya et al., 2021). Utilising the collected signatures, digital photographs have been classified. Five courses have been

created based on the signature provided, which covers the whole study area. Based on the calibre of the results, training samples were modified till an acceptable conclusion was reached. Agricultural and horticultural characteristics, fallow land, scrubs, forests, snow, and water features were used to group images into classes. ERDAS Imagine14.0 was used to create the normalised difference vegetation index for LANDSAT images taken between 2000 and 2020. To identify changes in land use patterns, the same procedure and change detection approach were applied from 2000 to 2020.

Result and Discussion :

Land use/ Land cover change (2000-2020) :

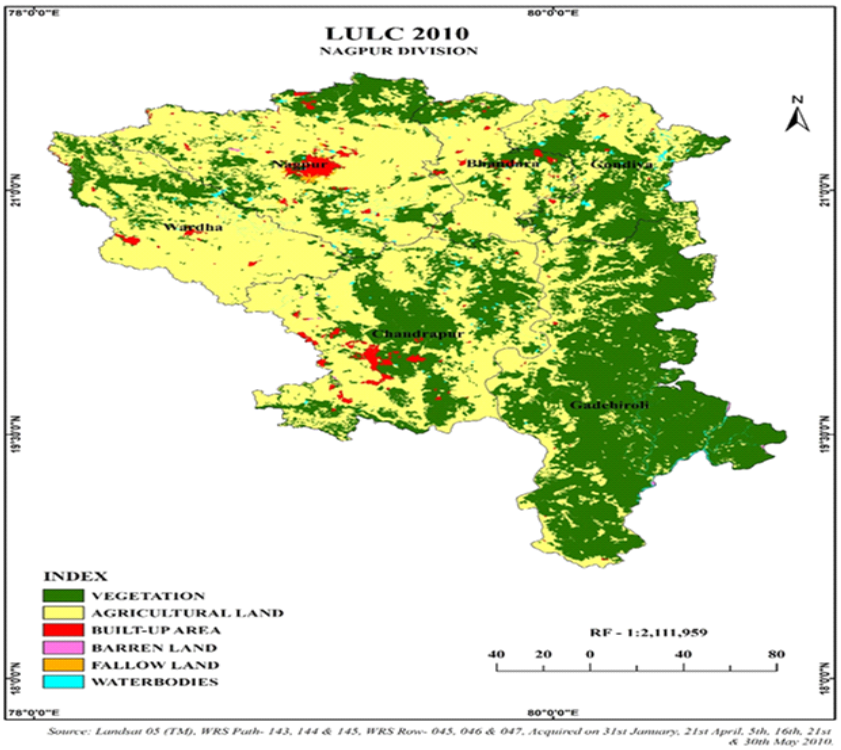
Land use and land cover refer to the physical and functional characteristics of land areas, including the types of land uses (such as agriculture, urban areas,



Source: Prepared by Research Scholar, 2022

Figure 2 : Land Use Land Cover of Vidarbha Nagpur Division, 2000

forests, etc.) and the natural or artificial coverings (such as vegetation, water bodies, built-up structures, etc.) on the Earth's surface (Pandey et al., 2021). Here is an overview of the changes in land use and land cover from 2000 to 2020. In the current study, satellite images from Landsat 7 (TM) for 2000, Landsat 5 (TM) for 2010, and 2020 (Landsat 8 OLI/TIRS) were utilised to examine the change in land use and land cover in the Nagpur division. Supervised classification was carried out using the maximum likelihood classifier method.

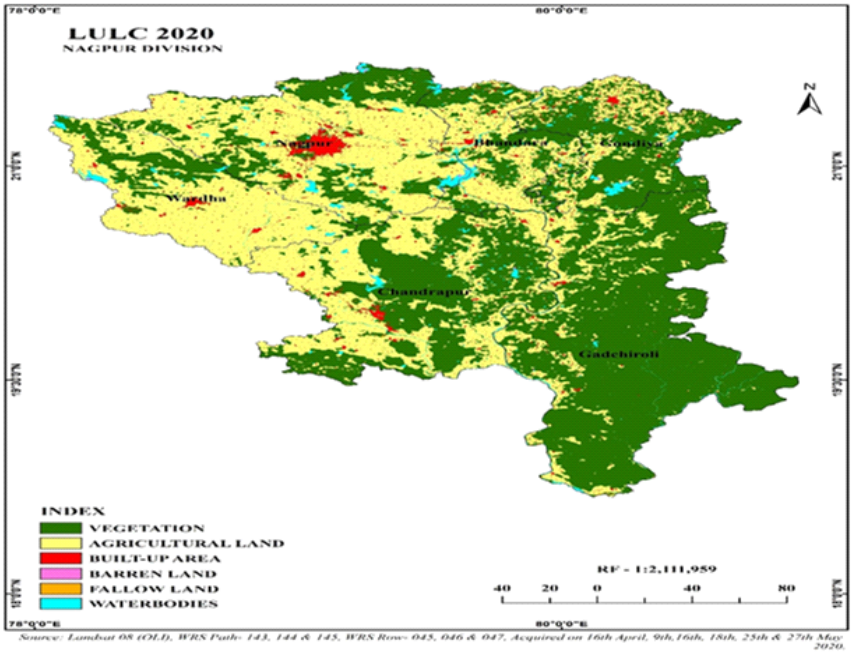


Source: Prepared by Research Scholar, 2022

Figure 3 : Land Use Land Cover of Nagpur Division, 2010

Nagpur district is bordered on the north by the Madhya Pradesh districts of Chindwada and Seoni and on the east by the district of Bhandara. The districts to the south and west are Chandrapur and Wardha, respectively. Thus, a section of the northwest is covered by the Amravati district. There are both natural and man-made ponds in the Nagpur district. Ambajari Lake is the largest lake in this region. Two further natural ponds are the Telangkhedi and Gorewada lakes. The city's mediaeval kings created the talukas of Gandhisagar and Sonegaon. Sewage is transported to

the city through natural rivers such the Pili River, Nag River, and numerous nalla. The city of Nagpur is renowned for its greenery. Only Chhattisgarh has been deemed the greenest and cleanest city in India, with Nagpur coming in second. Natural resources abound in Nagpur. The district is wealthy in soyabean, jowar, and mineral resources in addition to agriculture. The district's leading producer of vegetables and grasses is Nagpur. Additionally, this region has substantial manganese deposits.



Source: Prepared by Research Scholar, 2022

Figure 4 : Land Use Land Cover of Nagpur Division, 2020

According to the Nagpur LULC, the vegetation cover increased from 23919.63 sq. km in 2000 to 23114.48 sq. km in 2010. Data and a map reveal that there has been an increase in vegetation cover during the past ten years, with a total change in vegetation cover of 804.52 sq. km between the time periods (2000-2010) 26345.09 to 26961.56 sq. km, the built-up area of the study area has marginally grown. Water bodies were stable during the 10-years period, i.e., 62.01 and 344.09 sq. km of bare land grew from 19.62 to 37.84 sq. km.

The Nagpur division's LULC for the years 2010 to 2020 reveals both significant and modest changes as a result of economic and developmental activity

brought on by the region's industrialization and population growth (Fig. 1). The LULC was also impacted by population in-migration and out-migration brought on by economic development. The vegetative cover, which was 23114.48 square kilometres in 2010 but has been growing since 2000, will be 15269.05 sq. km in 2020. The built-up area in this region has significantly altered; it was 843.72 sq. km in 2010 and will be 1509 sq. km in 2020. In 2020, the area of waste land grew slightly to 43.22. The following land has seen significant changes, growing to 122.73 sq. km in 2020 from 62.01 sq. km in 2010. The water bodies shrank from 344.09 sq. km in 2010 to 126.78 sq. km in 2020 (Fig. 2). It demonstrates the effect of regional development initiatives on LULC.

Table 2 : Nagpur Division Land use/Land covers Change 2000-2020

Land Use Classes		Vegetation	Agricultural Land	Built-up Area	Barren Land	Fallow Land	Water bodies
2000	Area in (Km^2)	23919.59	26345.09	665.38	29.62	62.01	342.02
	%	46.57	51.29	1.3	0.06	0.12	0.67
2010	Area in (Km^2)	23114.48	26961.56	843.72	37.84	62.02	344.09
	%	45	52.49	1.64	0.07	0.12	0.67
2020	Area in (Km^2)	23249.05	26119.03	1509.88	136.22	122.75	226.78
	%	45.26	50.85	2.94	0.27	0.24	0.44
Change Between (2000-2010)	(in %)	-1.57	1.2	0.35	0.02	0	0
Change Between (2010-2020)	(in %)	0.26	-1.64	1.3	0.19	0.12	-0.23

Source: USGS, Earth Explorer, 2020

The change in land use and land cover in the Nagpur division from 2000 to 2020 is depicted in the table. The least amount of space is occupied by bare ground. Agricultural land still makes up the majority of the area, but it rose by 2.45 per cent

(51.29 sq. km) in 2000, continuing the same pattern. The amount of vegetation has shrunk by -0.73 per cent. The area of land occupied by waterbodies has shrunk the greatest; from 1463.91 sq. km in 1990 to 2000, it fell by -2.18 per cent. In 2010, the area covered by vegetation declined by -1.57% (23114.48 sq. km), accounting for 45 per cent of the study region's total land area. Land used for agriculture has gone up by 1.2 per cent. Since 1990, the built-up area has steadily increased (Table 2). The area occupied by water and adjacent land remained stable between 2000 and 2010. Between the year 2010 and 2020, the amount of vegetation rose by 0.26 per cent (Fig. 3). The area used for agriculture shrank by -1.64 per cent. In 2010, it had 51.29 sq. km, but by 2020, that had decreased to 50.85 sq. km. Once more, the area occupied by aquatic bodies shows a decline of -0.23. Because to construction activity and other economic developments, built-up has been rising since 1990.

Conclusion :

Agriculture holds immense importance globally, nationally, and at the state level in Maharashtra. It ensures food security, drives economic growth, and sustains rural livelihoods. Recognizing the significance of agriculture and implementing policies and initiatives that promote sustainable farming practices, technological advancements, and market access can enhance the livelihoods of farmers, reduce poverty, and contribute to overall development. By conducting a comprehensive spatio-temporal analysis of land use, land cover, and agriculture in the Nagpur Division of Vidarbha, this study aims to provide valuable insights into the region's changing landscape, agricultural dynamics, and associated challenges. The results can contribute to the formulation of sustainable development strategies, conservation initiatives, and informed policy decisions to ensure the region's socio-economic growth while preserving its natural resources. Due to rapid development and growth land use and land cover has been changed rapidly. Govt. agencies should ensure that rapid growth and development should be sustainable for the environment and human beings.

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