International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 05 | May 2023 www.irjet.net p-ISSN: 2395-0072

Remote Sensing and GIS-Based Monitoring of Land Use Change in Nagpur District: Insights and Implications

Tauseef Ahmad Ansari, Dr.Wael Albawwab

Assistant Professor[1], College of Engineering, University of Buraimi, Oman.
Assistant Professor[2], College of Engineering, University of Buraimi, Oman.

Abstract:

Land use and land cover are significant factors for making informed decisions across global, regional, and urban contexts. However, accurately assessing changes in land use and land cover over short periods of time presents significant challenges. The city of Nagpur has experienced rapid development, characterized by large-scale infrastructure projects that have negatively impacted various hydrological parameters. This research paper investigates the spatial and temporal changes in land use within Nagpur District between 2002 and 2016. The findings indicate a notable increase in built-up areas and fallow lands, spanning approximately 10 to 47 km^2 and 164 to 2063 km^2, respectively. Conversely, there has been a reduction in crop lands, forest lands, and water bodies, ranging from 57 to 2372 km^2, 112 km^2, and 189 km^2, respectively. Water bodies have also witnessed a decline ranging from 19 to 74 km^2. These findings underscore the necessity for effective urban watershed management practices to safeguard the hydrological parameters in the region.

Key Words: Land Use/ Land Cover, Remote Sensing and GIS, Urbanisation, Nagpur District.

Introduction:

Land use and Land cover (LU/LC) are critical components that shape the dynamics of the environment. They refer to the classification and distribution of various land types and their associated characteristics. The process of urbanization, driven by factors such as population growth and economic development, has a profound impact on LU/LC patterns and, consequently, on hydrological parameters. LU/LC serves as an essential indicator of catchment area characteristics, influencing the hydrological response of a region. Changes in land use, especially in urban areas, can significantly alter the natural hydrological cycle. Urbanization typically involves the conversion of natural landscapes, such as agricultural fields, forests, and water bodies, into built-up areas, resulting in increased impervious surfaces and reduced infiltration capacities. This transformation leads to changes in surface runoff patterns, increased flood risks, altered streamflow regimes, and modifications in groundwater recharge rates. The scientific investigation of LU/LC changes and their hydrological implications is crucial for understanding the impacts of urbanization on water resources. Several studies have investigated the relationship between urbanization and LU/LC changes. For example, research conducted by Samant et al. (1998) focused on Mumbai and highlighted the significant influence of population pressure on land use changes within the city. Similarly, Praful et al. (2011) examined land use transformations in the semi-arid region of Madhya Pradesh state, shedding light on the implications of changing land cover on local hydrological conditions. Another study by Sundar Kumar et al. (2012) investigated the drastic alterations in LU/LC that occurred in Vijayawada city between 1973 and 2009, providing valuable insights into the spatial and temporal dynamics of land use changes and their hydrological consequences. Sreenivasulu G. et al. (2013) utilized RS and GIS techniques to study LU/LC changes in the Vempalli area of Kadapa district, Andhra Pradesh, India, contributing to a better understanding of land use patterns and their effects on local hydrological resources. In one of the study by Pramod M. et al. (2014), the authors employed RS and GIS to examine land use changes and drainage patterns in Andhra Pradesh, India, facilitating the identification of areas susceptible to hydrological risks and the development of appropriate management strategies. Furthermore, Surya and Sumant (2016) conducted a district-wise analysis of land use changes in the capital city of India, providing comprehensive insights into the urbanization-induced LU/LC modifications and their implications for hydrological processes.

In recent years, a growing number of scientists have embraced the use of remote sensing and geographical information systems (GIS) technology for investigating land use and land cover changes. Researchers such as Praveen et al. (2013), Santosh et al. (2015), Hassan et al. (2016), Gogoi et al. (2019), Prabuddh et al. (2019), Prem et al. (2019), Biswajit et al. (2020), and Joseph et al. (2020) have contributed to this emerging field of study. The detection and analysis of land use and land cover changes are typically accomplished by comparing different time period images and utilizing diverse datasets that provide information on specific land use categories. These datasets may include information on built-up areas, croplands, fallow lands, and water bodies, among others. By examining changes in these land use categories, researchers can gain insights into the evolving landscape patterns and associated environmental dynamics.

The focus of this particular study is on the detection and analysis of land use and land cover changes within Nagpur District from 2002 to 2016. In the results section of the paper, the study present a detailed examination of the spatial and temporal changes that occurred within Nagpur District during the specified time period. These changes are described and analyzed in terms of the observed modifications in land use and land cover categories, providing valuable insights into the evolving landscape dynamics of the region.

Study Area:

Nagpur District, situated in the central part of Maharashtra state, India, has been carefully selected as the study area due to its unique characteristics and importance in the context of the research objectives. Spanning an expansive total area of approximately 9903.68 km^2, Nagpur District presents a diverse landscape for in-depth analysis. At the core of this district lies Nagpur city, a bustling urban center that serves as a hub of economic and cultural activities. As the administrative, commercial, and political capital of the region, Nagpur city showcases the complexities and dynamics of urbanization within the district. The hydrological features of Nagpur District are notably influenced by the presence of significant rivers.

The Pench river, Kanhan river, Kolar river, Nag river, and Pili river traverse through various parts of the district, shaping the hydrological network and contributing to the overall water resource availability. Geographically, Nagpur District is positioned at the coordinates of 21° 8′ 40.95″N latitude and 79° 05′ 31.63″E longitude. These geographical coordinates precisely locate the district within the Earth's coordinate system and serve as a reference for spatial analysis and mapping. A visual representation of the study area, depicted in Figure 1, provides a comprehensive overview of the geographical extent and spatial distribution of Nagpur District. This visual aid enhances the understanding of the study area's boundaries and spatial relationships, facilitating effective data interpretation and analysis.

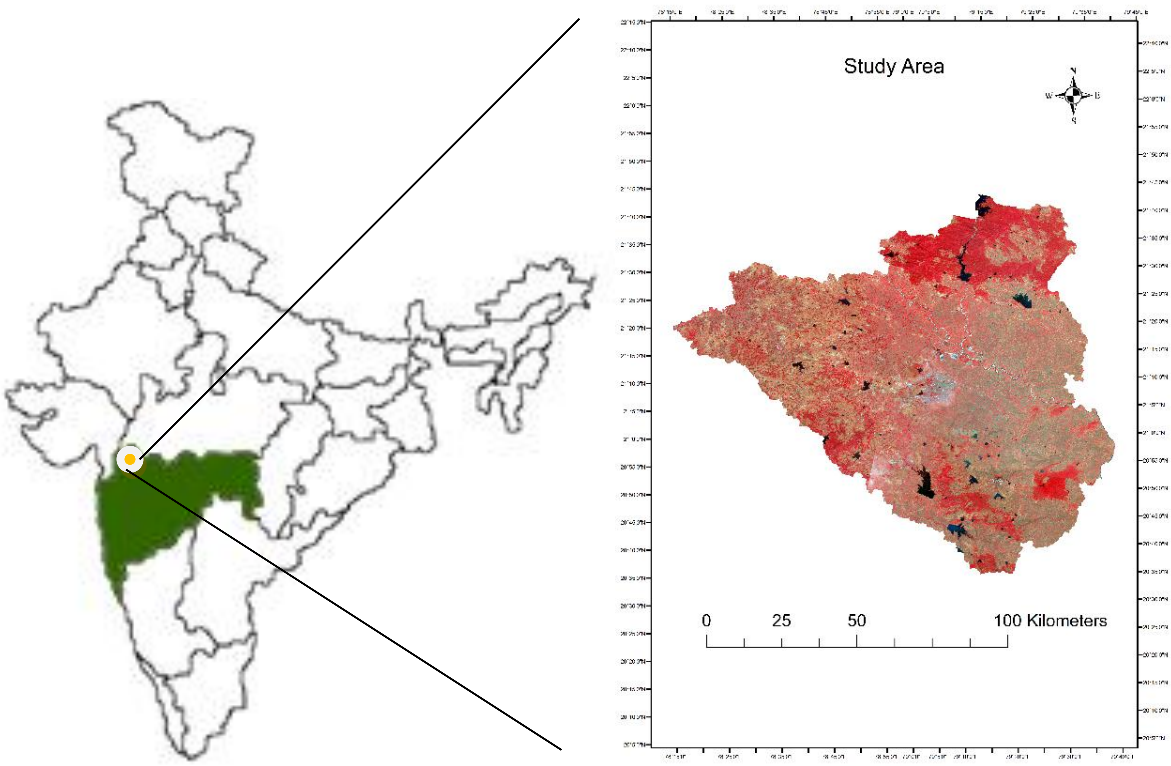

Figure 1 Illustrate the study area within Maharashtra state, India

Aim and Objectives:

The central objective of this study is to comprehensively examine and detect the temporal changes that have taken place in the land use and land cover patterns within Nagpur District. Specifically, the study focuses on analysing the variations occurring in different years, namely 2002, 2004, 2006, 2008, 2010, 2014, and 2016. To achieve this objective, high spatial resolution satellite data is employed as a valuable resource for capturing and assessing the intricate details of the land surface.

Methodology:

In this paper remote sensing and GIS technique has been used to estimate the various LU/LC classes occurred in the area. The satellite data of year 2002, 2004, 2006, 2008, 2010, 2014 and 2016 has been used for the study. The Arc GIS software has been used for digitisation process on the satellite image. After digitisation of the various LU/LC, the area of each classes were estimated and compared. The overall methodology has been given in the Figure 2.

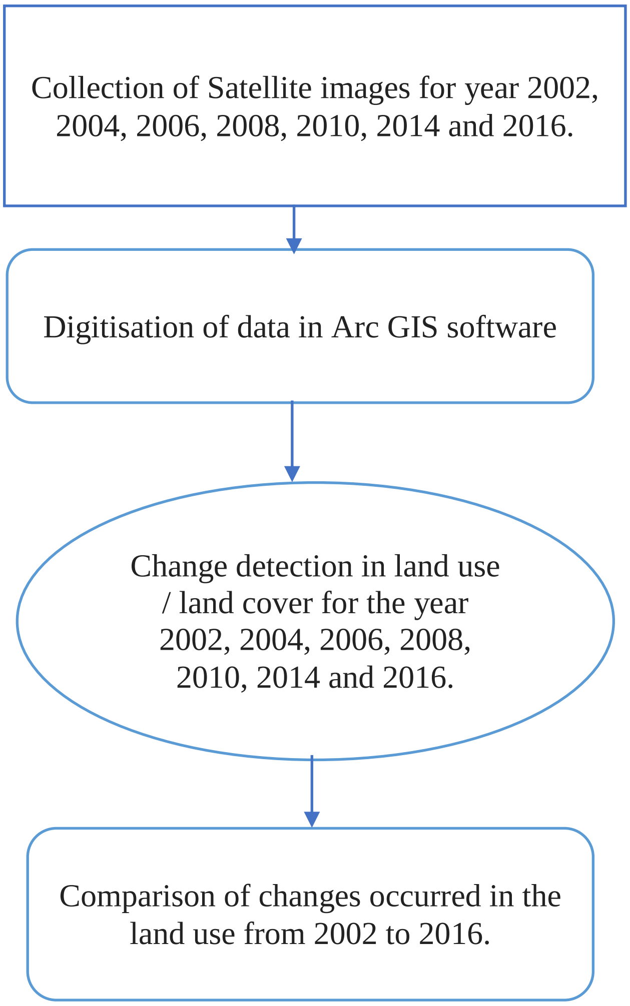

Figure 2 The adopted methodology depicted for conducting change detection in the study.

Results and Discussion:

The Nagpur District experienced significant developmental initiatives following the year 2000 as part of the government of India's five-year development plan. Consequently, this timeframe was selected to monitor and assess changes in the land use patterns within the region. The findings of the study reveal a notable increase in built-up areas and fallow land, accompanied by a decrease in crop land, forest land, and water bodies from 2002 to 2016. This observed transformation can be attributed to rapid urbanization, industrialization, and human activities, resulting in the conversion of crop land, forest land, and fallow land. Specifically, the built-up area expanded within a range of 10 to 47 km^2, while fallow land increased between 164 and 2063 km². In contrast, crop land, forest land, and water bodies experienced reductions ranging from 57 to 2372 km², 112 km², and 189 km² respectively. Furthermore, the area covered by water bodies decreased within the range of 19 to 74 square km², as outlined in Table 1 and Table 2.

Table 1 Land use changed in Nagpur District from year 2002-2016.

Sr. No.	Land use / land cover	2002 (Km²)	2004 (Km²)	2006 (Km²)	2008 (Km²)	2010 (Km²)	2014 (Km²)	2016 (Km²)
1	Built up Area	301.57	321.63	334.21	356.97	373.70	420.726	430.765
2	Crop Land	5522.46	5448.06	5339.09	4020.91	3962.96	5705.2	3332.66
3	Fallow Land	1565.93	1751.83	1504.74	3228.12	3392.99	1718.06	3780.83
4	Forest Land	2293.17	2181.13	2594.03	2158.47	2029.80	1840.49	2211.95
5	Water Body	220.55	201.20	131.62	139.21	144.21	219.20	147.52
	Total	9903.68	9903.68	9903.68	9903.68	9903.68	9903.68	9903.68

Table 2 Changes in Land Use Classes: Increase/Decrease from 2002 to 2016"

Sr. No.	Land Use/ Land Cover	2002-2004	2006-2008	2010-2014	2014-2016
1	Built up Area	+20.066	-22.76	-47.026	-10.039
2	Crop Land	-74.394	+1318.18	-1742.235	+2372.54
3	Fallow Land	+185.903	-1723.38	+1674.935	-2062.77
4	Forest Land	-112.034	+435.56	+189.315	-371.46
5	Water Body	-19.344	-7.59	-74.99	+71.68

Table 2 presents the changes in land use/land cover classes, where a positive sign signifies an increase and a negative sign indicates a decrease. The trend depicted in Figure 3 demonstrates an overall increase in the built-up and fallow land area between 2002 and 2016.

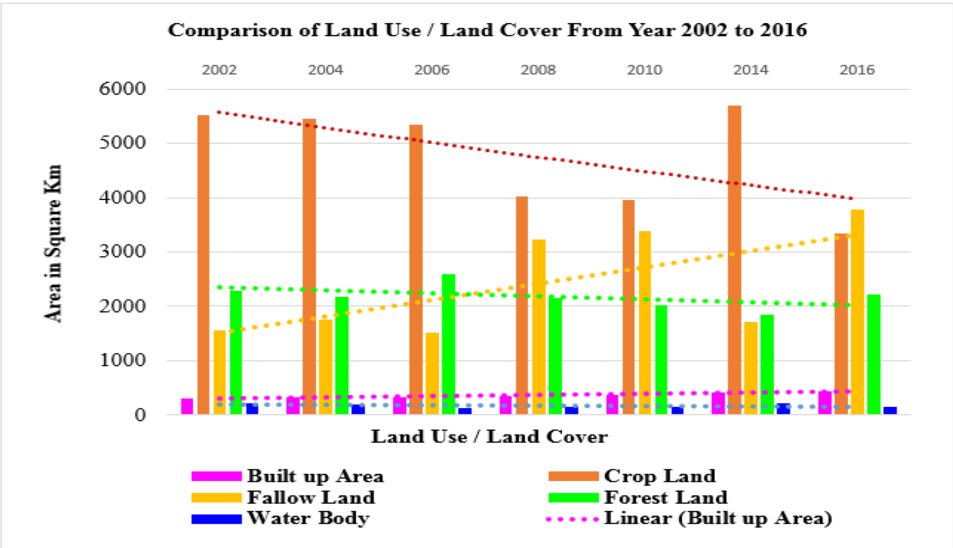

Figure 3 Comparative Analysis of Land Use Classes across Nagpur District from 2002 to 2016"

Figure 4 illustrates the increase in built-up and fallow land areas, accompanied by a decrease in crop land, forest land, and water bodies between the years 2002 and 2004.

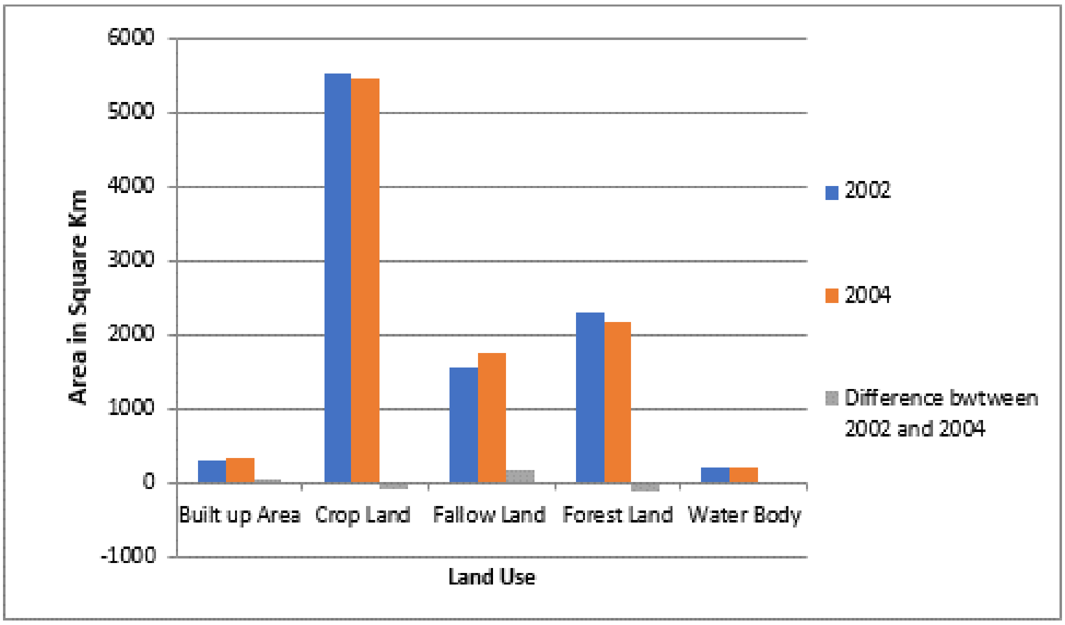

Figure 4 Comparative Analysis of Land Use Classes: between 2002 and 2004.

Likewise, Figure 5 demonstrates the expansion of built-up and fallow land areas, alongside the decline of crop land, forest land, and water bodies observed between the years 2006 and 2008.

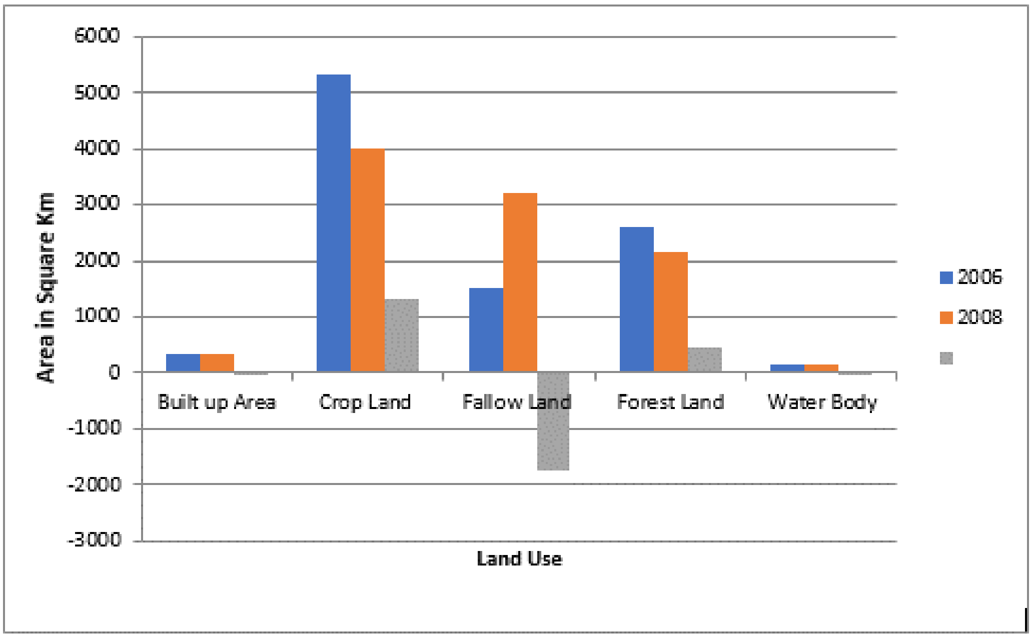

Figure 5 Comparative Analysis of Land Use Classes: between 2006-2008

Figure 6 depicts the increase in built-up areas, crop land, and water bodies, accompanied by a decrease in fallow land and forest area observed between the years 2010 and 2014.

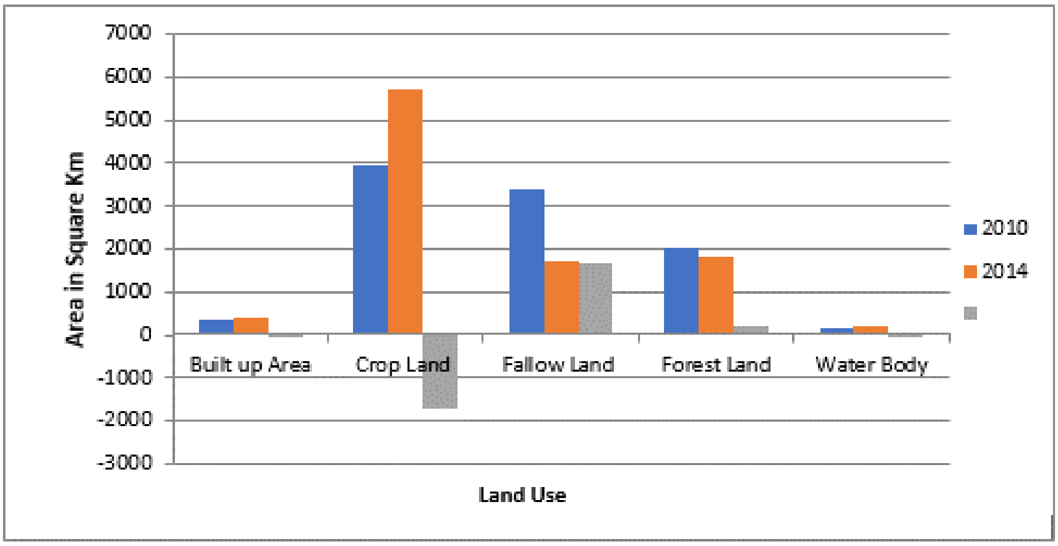

Figure 6 Comparative Analysis of Land Use Classes: between 2010-2014

Figure 7 illustrates the increase in built-up areas, fallow land, and forest area, while indicating a decrease in crop land and water bodies between the years 2010 and 2014.

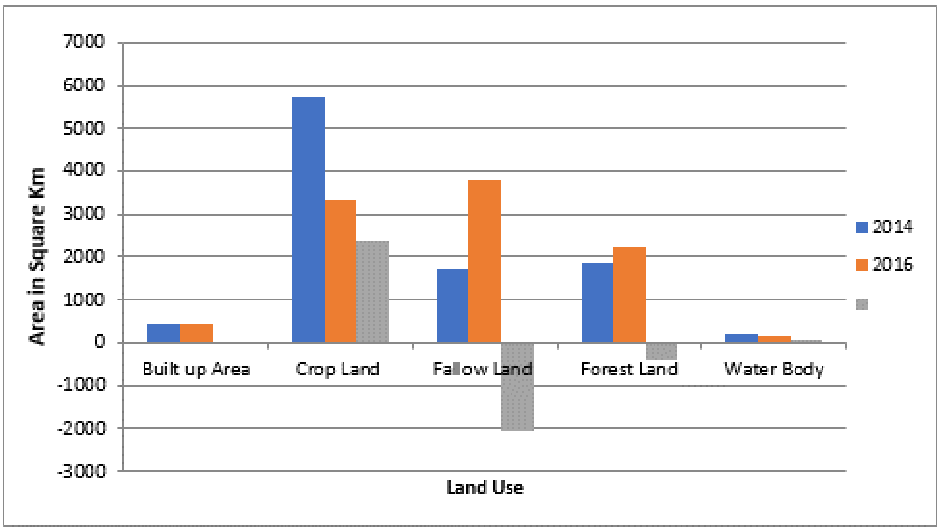

Figure 7 Comparative Analysis of Land Use Classes: between 2014-2016.

The study employs a detailed analysis of land use patterns, focusing on five key land use classes within the study area. These classes include built-up areas, water bodies, forest land, fallow land, and crop land. Each land use class is visually represented using distinct colors and patterns on the land use map. The use of green color to represent forest land is justified by its association with natural vegetation. This color identifies and distinguish areas covered by dense vegetation. Similarly, the representation of crop land using green color with dots is justified by the need to differentiate it from forest land. Water bodies are assigned a blue color, a common representation widely recognized for bodies of water such as rivers, lakes, and reservoirs. Blue color provides a clear visual distinction, allowing for the identification and analysis of water bodies within the study area. Fallow land, denoting agricultural land left uncultivated for a specific period, is represented in yellow color. This color choice differentiates fallow land from other land use classes and helps highlight areas where agricultural activities have been suspended or rotated. Lastly, built-up areas, representing urban or developed regions, are depicted using a shaded orange color (Figure 8).

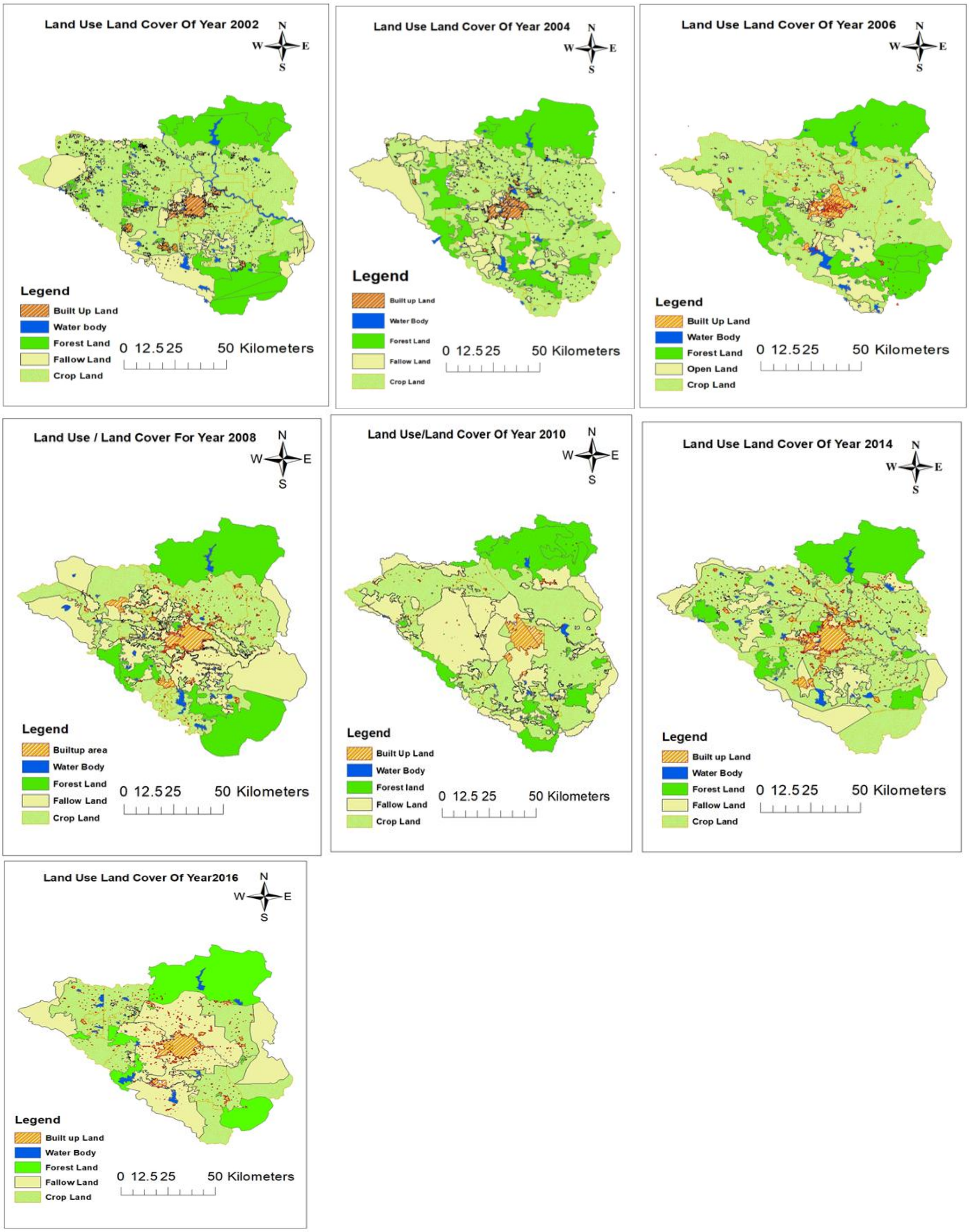

Figure 8 Spatial and temporal changes in the land use pattern in Nagpur District from year 2002 to 2016.

Conclusions:

The following conclusions can be derived from the study:

- Land use and land cover play a crucial role in decision-making processes across global, regional, and urban contexts.
- Assessing changes in land use and land cover over short periods of time presents significant challenges.
- The city of Nagpur has undergone rapid development, characterized by large-scale infrastructure projects that have negatively impacted hydrological parameters.
- The study revealed an increase in built-up areas and fallow lands, spanning approximately 10 to 47 km^2 and 164 to 2063 km^2, respectively.
- Conversely, there has been a reduction in crop lands, forest lands, and water bodies, ranging from 57 to 2372 km^2, 112 km^2, and 189 km^2, respectively.
- Water bodies have also witnessed a decline ranging from 19 to 74 km^2 area.
- Effective urban watershed management practices are necessary to safeguard the hydrological parameters in the region.
- Sustainable measures should be implemented to mitigate the adverse effects of rapid urbanization and industrialization on crop lands, forest lands, and water bodies.
- Maintaining a balance between development and the conservation of ecological resources is essential for the long-term sustainability and resilience of Nagpur District's hydrological systems.

References:

Biswajit Nath, Zhihua Wang, Yong Ge, Kamrul Islam, Ramesh P. Singh and Zheng Niu, (2020) "Land Use and Land Cover Change Modeling and Future Potential Landscape Risk Assessment Using Markov-CA Model and Analytical Hierarchy Process." ISPRS Int. J. Geo-Inf. 2020, 9, 134; doi: 10.3390/ijgi9020134.

Gogoi, P.P., Vinoj, V., Swain, D. et al. Land use and land cover change effect on surface temperature over Eastern India. Sci Rep 9, 8859 (2019). https://doi.org/10.1038/s41598-019-45213-z.

Hassan, Z., Shabbir, R., Ahmad, S.S. et al., (2016), "Dynamics of land use and land cover change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan." Springer Plus 5, 812. https://doi.org/10.1186/s40064-016-2414-z

Joseph Spruce, John Bolten, Ibrahim N. Mohammed, Raghavan Srinivasan and Venkat Lakshmi., (2020), "Mapping Land Use Land Cover Change in the Lower Mekong Basin From 1997 to 2010." ORIGINAL RESEARCH, doi: 10.3389/fenvs.2020.00021.

Prabuddh Kumar Mishra Aman Rai, Suresh Chand Ra (2019) "Land use and land cover change detection using geospatial techniques in the Sikkim Himalaya, India." The Egyptian Journal of Remote Sensing and Space Science, https://doi.org/10.1016/j.ejrs.2019.02.001

Praful Singh, Jay Krishna Thakur, Suyash Kumar, U. C. Singh, (2011), "Assessment of Land Use/Land Cover Using Geospatial Techniques in a Semi-arid Region of Madhya Pradesh, India." Geospatial Techniques for Managing Environmental Resources, 2011, ISBN: 978-94-007-1857-9,

Pramod M. Kumar, K. Nagalakshmi, T. Lakshmi Prasad, N.Jayaraju ,B.Lakshmanna, (2019), "Land use and Land Cover Analysis using Remote Sensing and GIS: A Case Study in and around Bramhamgarimatam, Kadapa District, Andhra Pradesh, India" SSRG International Journal of Geoinformatics and Geological Science (SSRG -IJGGS) - Volume 6 Issue 1 – Jan to Apr 2019.

Praveen Kumar Mallupattu, and Jayarama Reddy Sreenivasula Reddy (2013), "Analysis of Land Use/Land Cover Changes Using Remote Sensing Data and GIS at an Urban Area, Tirupati, India." Volume 2013 |Article ID 268623, https://doi.org/10.1155/2013/268623.

Prem Chandra Pandey, Nikos Koutsias, George P. Petropoulos, Prashant K. Srivastava, Eyal Ben Dor, (2019), "Land use/land cover in view of earth observation: data sources, input dimensions, and classifiers—a review of the state of the art." Geocarto International, https://doi.org/10.1080/10106049.2019.1629647.

Samant, H., Subramanyan, V., (1998), "Landuse/land cover change in Mumbai-Navi Mumbai cities and its effects on the drainage basins and channels. A study using GIS." J Indian Soc Remote Sens 26, 1–6. https://doi.org/10.1007/BF03007333.

Santosh, Babar and H. Ramesh, (2015), "Streamflow Response to Land Use–Land Cover Change over the Nethravathi River Basin, India." Journal of Hydrologic Engineering, © ASCE, ISSN 1084-0699/05015002(11)/$25.00.

Sreenivasulu G., N. Jayaraju, M. Pramod Kumar, T. Lakshmi Prasad (2013), "An Analysis on Land Use/Land Cover Using Remote Sensing and GIS–A Case Study In and Around Vempalli, Kadapa District, Andhra Pradesh, India." International Journal of Scientific and Research Publications, Volume 3, Issue 5, May 2013 1 ISSN 2250-3153.

Sundarakumar K., M. Harika, Sk. Aspiya Begum, S. Yamini, K. Balakrishna, (2012). "Land Use and Land Cover Change Detection and Urban Sprawl Analysis of Vijayawada City Using Multi temporal Landsat Data." International Journal of Engineering Science and Technology (IJEST).

Surya Prakash Pattanayak and Sumant Kumar Diwakar, (2016), "District-Wise Change Analysis of Land Use-Land Cover In Delhi Territory Using Remote Sensing & GIS" Journal of Urban and Environmental Engineering, v.10, n.2, p.201-213, ISSN 1982-3932 doi: 10.4090/juee2016.v10n2.201213.