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Assessment of Land use Land Cover Changes in Peri-Urban Area of Bibi Nagar Mandal Case Study - Hyderabad Metropolitan Region

Sri devi.Turumella,
Ph.d. Scholar, School of Planning & Architecture,
JNA & FAU, Hyderabad, India

Dr. S. Kumar
Professor in Architecture,
School of Planning & Architecture,
JNA & FAU, Hyderabad, India

Abstract:- Due to population growth and limited space in cities, policymakers are expanding into peri-urban areas, impacting the natural landscape. These areas are attractive to developers due to available land and government policies. This expansion at the peri urban areas worsens the negative effects of urbanization on ecological and agricultural regions. Similar trends have been observed in Hyderabad after implementing Master plans in 2013 and Land pooling act in 2017. While these policies promote socioeconomic growth and infrastructure development, they harm the agriculture sector. This study uses GIS tools and remote sensing techniques to evaluate the impact of urban growth on farmland in peri-urban areas. LULC maps were created for five years using remote sensing data, cross-referenced with GPS data for accuracy assessment. The findings show significant changes over five years in Bibi Nagar Mandal's peri-urban area, including the transformation of agricultural land into developed areas. for infrastructure and residential projects.

Keywords:- *Peri urban Area, Land use/land cover, Detection of Change, Assessing Accuracy.*

I. INTRODUCTION

The rapid growth of urbanization is changing peri-urban areas. These rural zones on the outskirts of cities are becoming more active due to population booms, market currents, and development doctrines. This transformation has significant implications for nature, society, and earnings. Peri-urban places are feeling the impact of urbanization as their fields and farms are being replaced with concrete. We will examine how these changes affect the environment, community, and profits. Peri-urban areas are turning into bustling urban centers, affecting land cover and bringing consequences for nature, people, and economy. According to Saifullah et al. (2017), urban expansion in peri-urban regions is a major issue troubling regional strategist. This phenomenon, known as "peri-urban land use land cover conversions," involves the rapid transformation of rural landscapes into urban settlements beyond intended borders. The consequences include loss of biodiversity, displacement of residents, and increased pollution (Gomes et al., 2020). Urbanization and population growth are causing land scarcity. Therefore, information on optimal land use possibilities is essential for planning to meet increasing demands (Zubair et al., 2006; Praveen Kumar Mallupattu et al., 2013; Dires Tewabe et al., 2020). Analyzing changes in LULC helps understand the dynamic environment and ensures sustainable development (Xiulian Bai et al., 2017). It also plays a crucial role in ecological management, environmental planning, landscape changes, afforestation/deforestation assessment, water resources evaluation, mining activities monitoring, and industrial expansion analysis. Land use refers to human utilization of land for economic/cultural purposes such as agriculture, housing, industry, mining, recreation. Monitoring these changes over time is important for balancing conservation efforts with development needs. Land cover includes physical substances like vegetation and water bodies that must be identified/mapped/monitored globally to facilitate future planning initiatives. Satellite remote sensing data have proven invaluable for mapping LULC patterns/changes over time. After delineating satellite images into thematic maps, accuracy assessment is necessary to improve future LULC map quality. This study aims to identify LULC changes in the peri-urban zone of Hyderabad Metropolitan Region using ESRI Data and ArcGIS10.8. This area faces challenges due to rapid population growth, unplanned development, and inadequate infrastructure.

II. STUDY AREA

Bibi Nagar Mandal is located in Yadadri Bhuvangiri district, Telangana state. It lies between 17°28′ 20.54” N latitudes and 78°47′44.10” E longitudes. The area under investigation is the Mandal located in Hyderabad that ranks as the second largest Peri urban region in Hyderabad Metropolitan Region, with a total extent of 176.33 Sq.Km and a Peri urban extent of 60.48 Sq.Km. The boundaries are marked by Bhongiri, Ghatkesar, Bommalaramaram, and Pochampally. Bibi Nagar Mandal has seen economic growth recently due to connectivity, industries, and educational institutions. Urban population in 2001 was 45992 and in 2011 was 58513, reflecting urbanization rate.

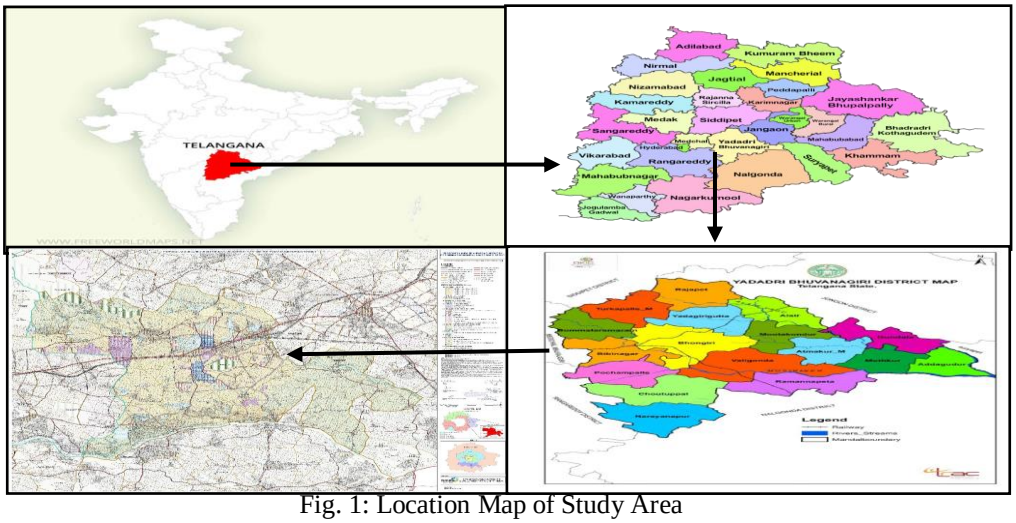

Fig. 1: Location Map of Study Area
Source: Secondary Data

III. METHODS AND METHODOLOGY

Land use and land cover changes in Bibi Nagar Mandal Peri urban Area were determined the utilization of remote sensing and geographic information system (GIS) methods. This involved acquiring and preparing data, implementing supervised classification, assessing accuracy, and conducting change detection analysis. The Master plan of Bibi Nagar was converted to a digital format through scanning. Georeferencing using ArcGIS software was performed on the topographic map to establish boundaries. Preprocessing was conducted on remote sensing data obtained from Esri-Sentinel-2 Explorer via ArcGIS for interpretation and the practice of managing information purposes. Empirical data obtained through direct observations collected with GPS were employed to corroborate the LULC categorization and evaluate image accuracy. Statistical analysis was performed on the resulting LULC maps to calculate changes in land use/land cover within the study area.

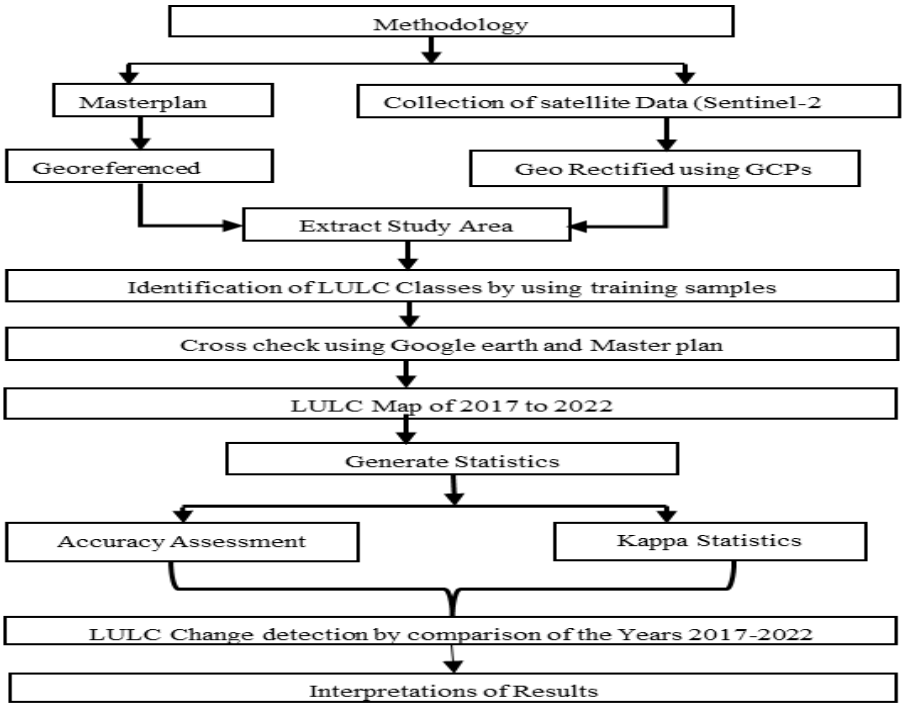

Fig. 2: Methodology adopted for Study Area

A. Image Processing

The global land use/land cover (LULC) map is accessible through Esri_Imagery. It is generated using Impact observatory's deep learning and AI model trained with manually annotated image pixels from the National Geographic Society. The model is applied to Microsoft's Planetary Computer, analyzing over 400,000 Earth observations annually from Sentinel-2 Level-2A images to produce LULC predictions for different categories.

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Table 1: Details of Satellite Images, Source: Esri

S.No.	Algorithm	Description
1	Variable mapped	Land use/land cover in 2017, 2018, 2019, 2020, 2021, 2022
2	Source Data Coordinate System	Universal Transverse Mercator (UTM) WGS84
3	Extent	Bibi Nagar
4	Source Imagery	Sentinel-2 L2A
5	Cell size	10-meters
6	Type	Thematic
7	Attribution	Esri, Impact observatory, and Microsoft

B. Image Classification

LULC classification was performed using the maximum likelihood algorithm. Remote sensing data and field observations were used to generate training sets. The raster output was converted to vector format using ESR Sentinel-2. The vector output was analyzed and prepared for mapping on ArcGIS 10.8. Multiple LULC maps were obtained for different time periods in the study area.

C. Assessing Accuracy

The precision of the LULC classification was evaluated for images depicting of 2022. Ground truth observations were obtained to represent land use/land cover classes in the study area. A total of 30 points were used for each class, determined through the process of acquiring accurate observations and analyzing them visually, as well as employing the error matrix approach. compared results of categorization using specific benchmarks, while the kappa factor measured accuracy. Independent validation was conducted for each map. Accuracy assessment data were collected using remote sensing across all years, with ground-truth verification in 2022. Verification locations from 2022 were plotted on subsequent images and used as additional verification sites to evaluate accuracy in that year.

D. Change Detection

The analysis of detecting change offers an assessment and quantification of the discrepancies amongst visuals captured at the identical site during separate time intervals. This method of analysis presents significant benefits in identifying various modifications in land usage and land coverage, including the growth of urbanized regions and the reduction of agricultural land. In this particular investigation, calculations were conducted to determine change detection statistics for the following periods: 2017-2018, 2018-2019, 2019-2020, 2020-2021, and 2021-2022.

IV. RESULTS AND DISCUSSIONS

The Figures 3 to 8 represents the resulting observations derived from the analysis of remote sensing data collected at multiple time intervals. The provided imagery visually depicts the current state of land use and land cover (LULC) in Bibi Nagar Mandal peri urban Area during six distinct study periods, ranging from 2017 to 2022. The classification of LULC patterns in this area encompasses seven discernible categories: Agriculture, Built-Up, Water bodies, Trees, Bare Ground, Flooded Vegetation, and Range Land.

The land use and cover classifications used in this analysis provide a comprehensive overview of the characteristics in the study area. The results show trends for 2017, with agricultural land at 52%, rangeland at 38%, built-up areas at 7%, trees at 2%, water bodies at 1%, and some bare ground. Similar findings are observed for 2018, with slight percentage variations. Data from subsequent years (2019-2020) reveal that agricultural land represents around 60% (35.89 sq.km) and 62% (37.38 sq.km), respectively. Rangeland occupies approximately32% (19.28 sq.km) in 2019, reducing to 26% (15.63 sq.km) by 2020.Built-up areas account for about7%(4.39sq.km), increasing slightly to approximately8%(5.11sq.km). Tree coverage expands significantly from 0.32% (0.19sq km) to roughly2% (1.35sq km). Water bodies constitute approximately 1% (0.69sq km), growing to roughly 2% (0.97sq km). Throughout this period, bare ground remains consistent at an additional area of roughly 0.04 sq km. The most recent data reflects primary land features observed in the study area during 2021: Agricultural land comprises roughly 63 %, Rangeland makes up around 25 %, Built-up areas account for 9 %, Tree coverage constitutes1 %, Water bodies occupy 2 %, and there is an additional 0.06Sq.km of Bare ground present.

The final classifications of land use and land cover show the primary features in the study area. The classifications depict the expansion and distribution of different types of land in 2022: 52% agricultural land, 35% rangeland, 10% built-up areas, 1% trees, and 2% water bodies. Some areas are classified as bare ground or flooded vegetation.

The study area consisted mostly of agricultural lands that were crucial for food production. However, there was a decline in agricultural land from 2017 to 2018, followed by an increase from 2019 to 2021. In 2022, there was a sudden decline indicating significant conversions within the region. Rangeland was the second most dominant land cover and showed a decreasing trend from 2017 to 2021 but grew in 2022 at the expense of agricultural lands.

The decrease in crop land is mainly due to its the utilization of water for non-agricultural activities and the diversion of water availability challenges. Additionally,

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built-up areas have consistently increased from 2017 to 2022, showing a positive correlation between the loss of agricultural lands and the growth of built-up areas coinciding with population expansion.

A. Assessing Accuracy

Accuracy assessment is crucial in land use and land cover change detection. The error matrix method was used to evaluate classification precision. By comparing outcomes with reference data, error matrices were utilized. The columns of the table represent categories from the classified image, while the rows correspond to categories from the point of reference. 30 points of reference were gathered for each land use/land cover class within the domain to ensure accurate results. Measures such as producer's accuracy, user's accuracy, overall accuracy, and kappa statistics were calculated using the error matrix method. Accuracy assessment results for 2022 are presented in Table No.3., which confirm that Figure 9 demonstrates ground-truth verification of land use and land cover, surpassing expectations in classification precision.

B. Change Rate Analysis

The findings from the analysis of changes in land use and land cover (LULC) in the peri-urban area of Bibi Nagar Mandal from 2017 to 2022 are shown in Table 2. The data indicates variations in both decreases and increases in LULC alterations over this five-year period. Agricultural land increased by 0.04%, Range land decreased by -2.40%, Built-up areas increased by 2.09%, Trees decreased by -0.18%, Water bodies increased by 0.43%, Bare Ground increased by 0.02%, and Flooded vegetation increased by 0.01%.

Table 2: LULC Change Rate Analysis, Source: Primary data

S.No.	LULC_CODE	2017	2018	2019	2020	2021	2022	Annual Change Rate	Inference
1	Agriculture	31.37	31.66	35.89	37.38	38.05	31.41	0.04	Increase
2	Range Land	23.23	22.66	19.28	15.63	15.02	20.83	-2.40	Decrease
3	Builtup	4.04	4.19	4.39	5.11	5.16	6.13	2.09	Increase
4	Trees	1.00	1.09	0.19	1.35	0.88	0.82	-0.18	Decrease
5	Water Body	0.76	0.82	0.69	0.97	1.30	1.19	0.43	Increase
6	Bare Ground	0.07	0.05	0.04	0.04	0.06	0.10	0.02	Increase
7	Flooded Vegetation	0.00	0.00	0.00	0.00	0.00	0.01	0.01	Increase

The changes in land use and cover in the peri-urban area of Bibi Nagar are influenced by various factors, including natural and human-induced elements. Population growth is the main driver of urban expansion, but it is important to consider the effects amongst other variables such as environmental and the impacts of socio-economic factors influences. Urbanization has caused environmental challenges for both developing and developed nations.

According to census data, there has been a significant increase in population in the study region from 2001 to 2011. Rural-to-urban migration has caused pressure on natural resources and conversion of agricultural lands into developed areas. The real estate sector is important for expanding industrial activities and developing barren lands.

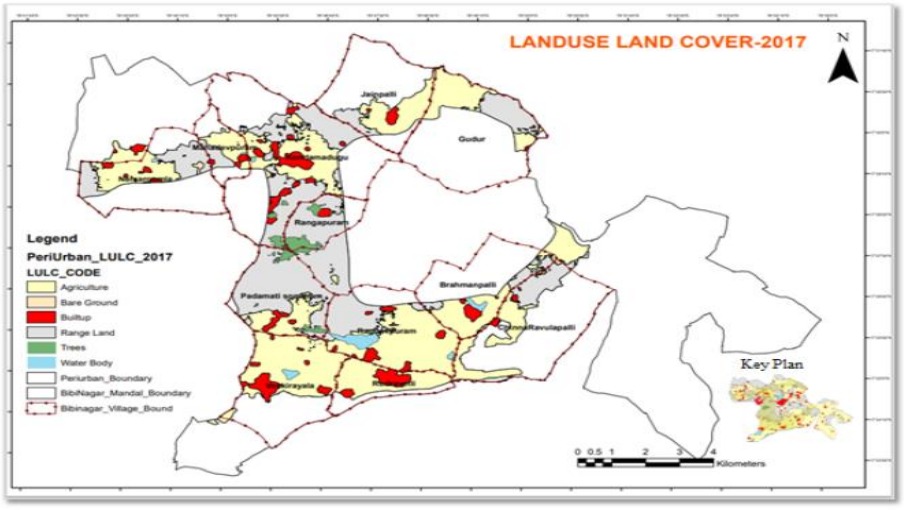

Fig. 3: LULC Map of Peri Urban Area of Mandal in 2017
Source: Primary data

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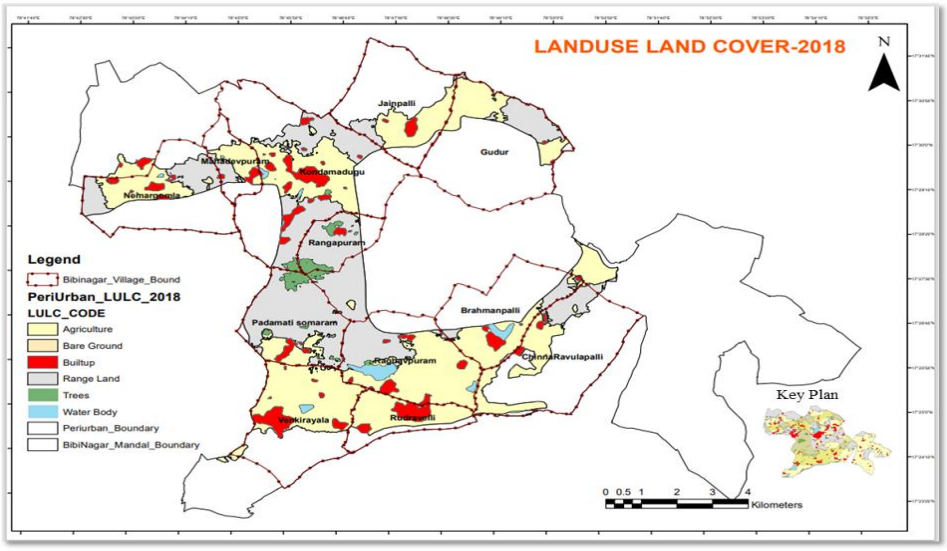

Fig. 4: LULC Map of Peri Urban Area of Mandal in 2018
Source: Primary data

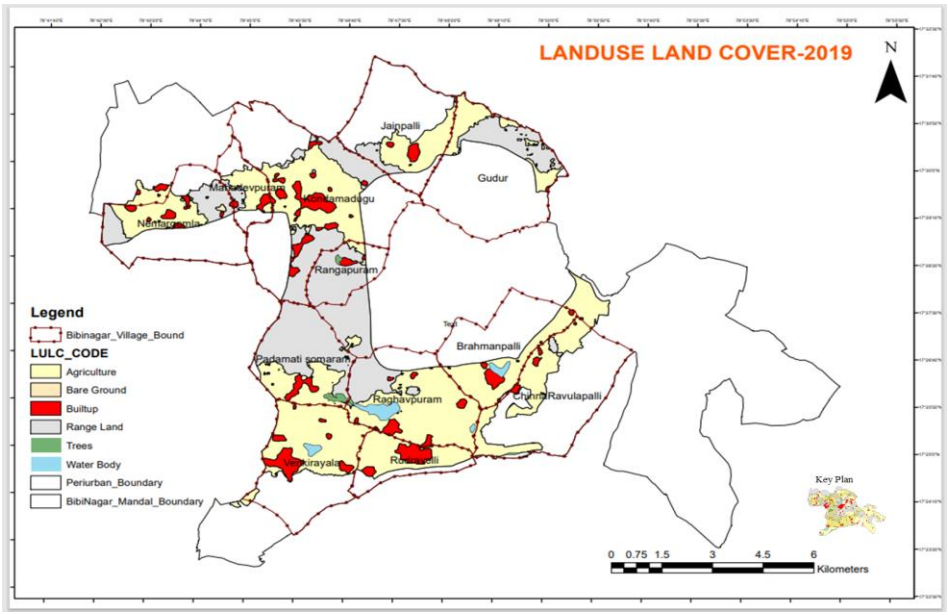

Fig. 5: LULC Map of Peri Urban Area of Mandal in 2019
Source: Primary data

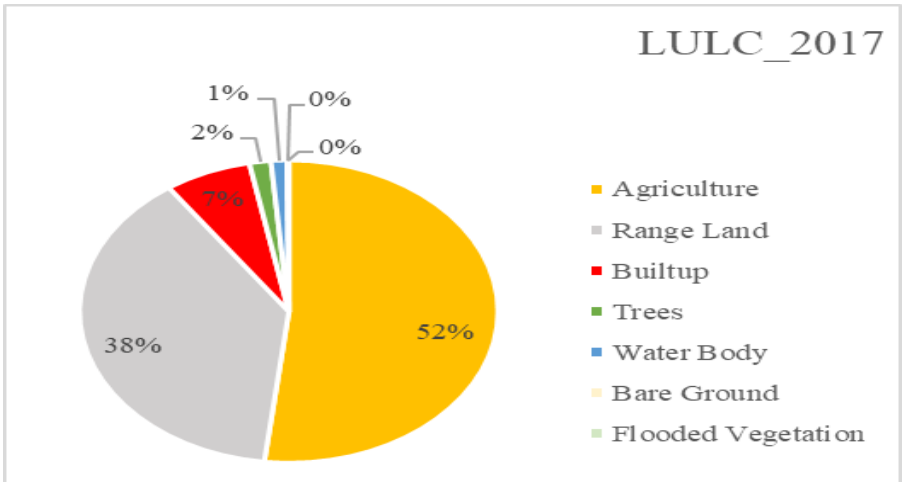

Fig. 6: LULC Map of Peri Urban Area of Mandal in 2017
Source: Primary data

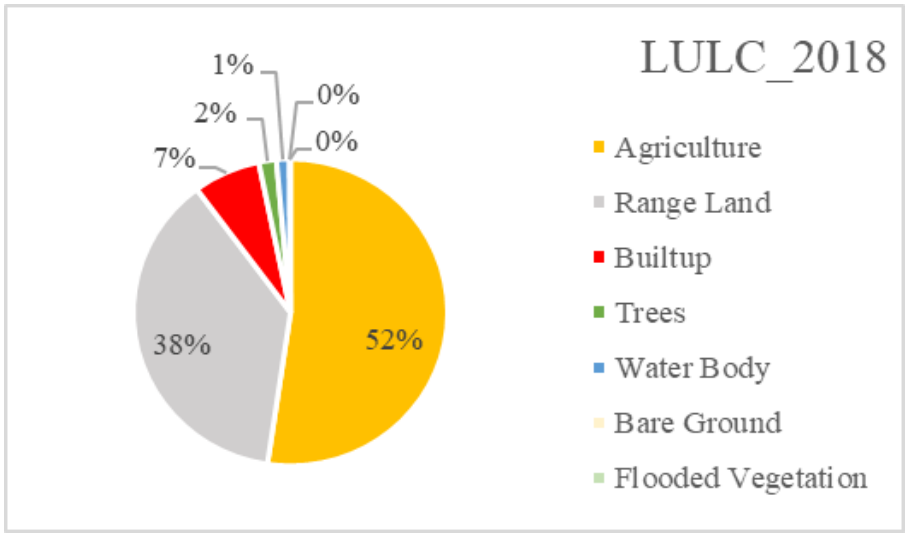

Fig. 7: LULC Analysis of Peri Urban Area of Mandal in 2018
Source: Primary data

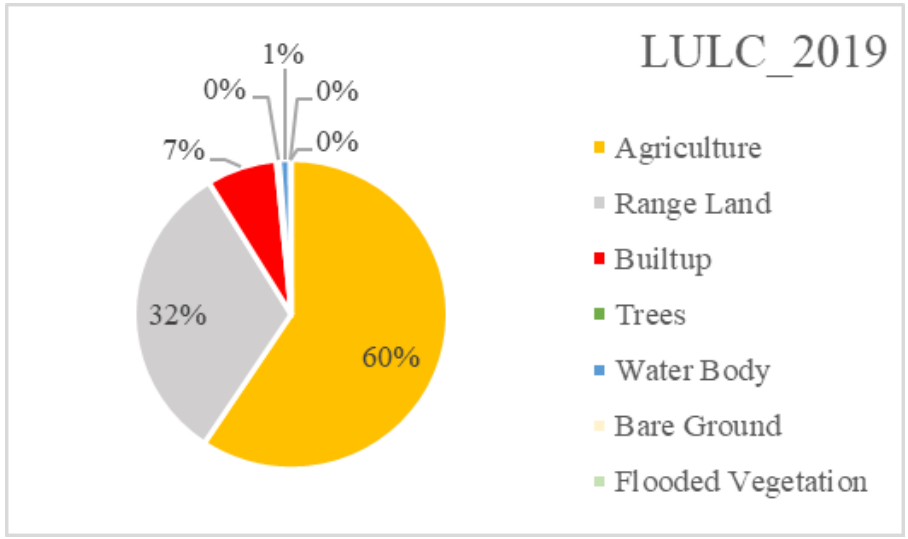

Fig. 8: LULC Analysis of Peri Urban Area of Mandal in 2019
Source: Primary data

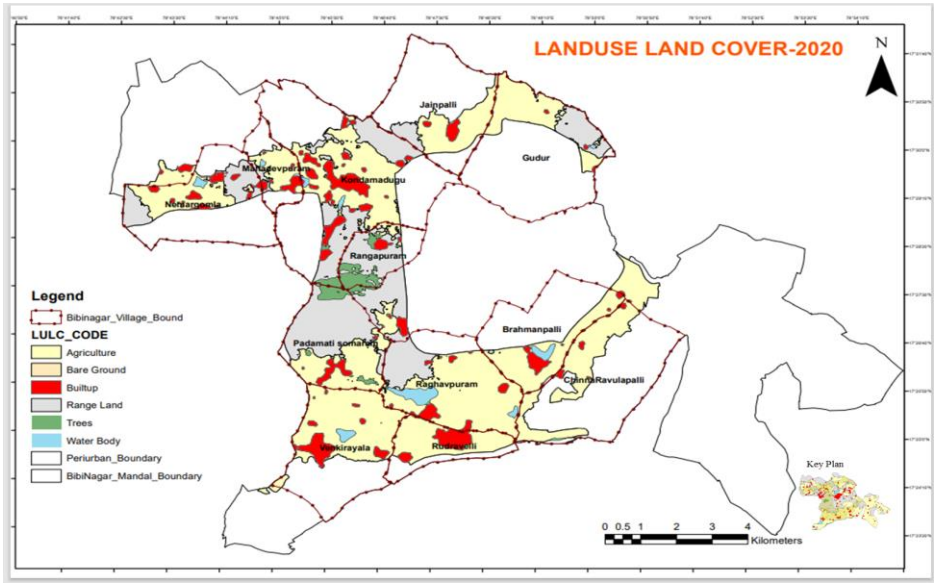

Fig. 9: LULC Map of Peri Urban Area of Mandal in 2020
Source: Primary data

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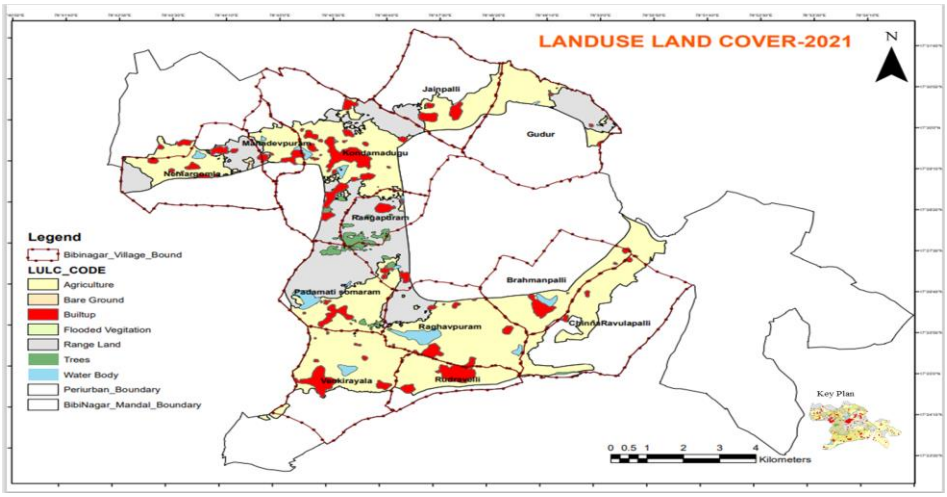

Fig. 10: LULC Map of Peri Urban Area of Mandal in 2021
Source: Primary data

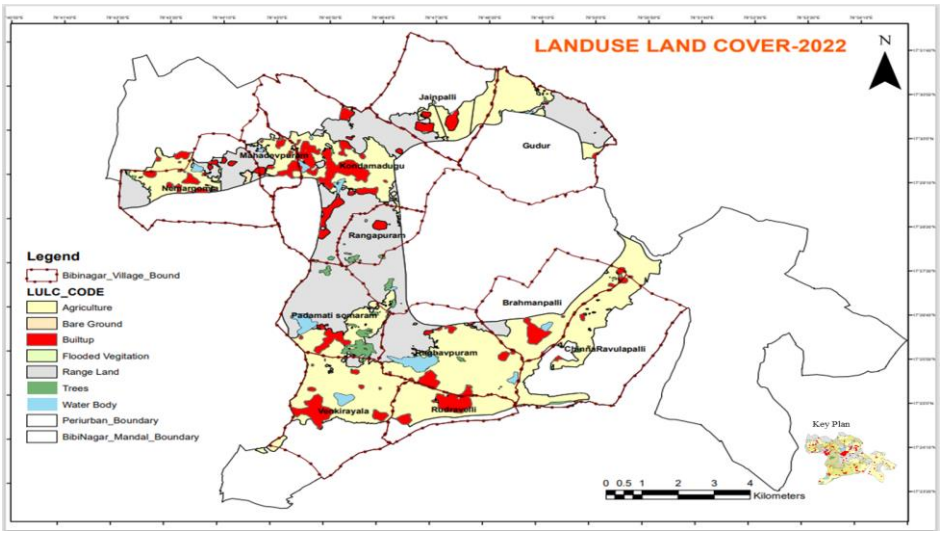

Fig. 11: ULC Map of Peri Urban Area of Mandal in 2022
Source: Primary data

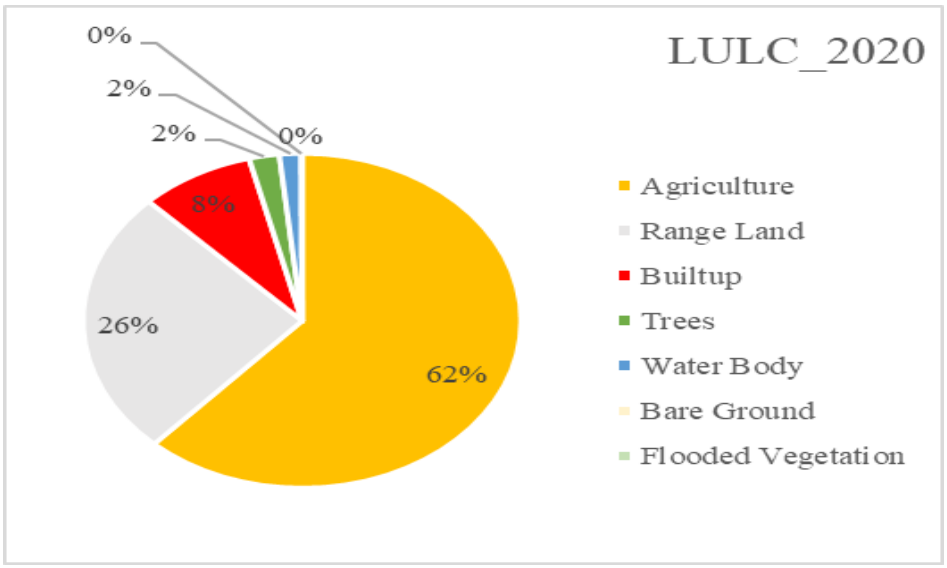

Fig. 12: LULC Analysis of Peri Urban Area of Mandal in 2020
Source: Primary data

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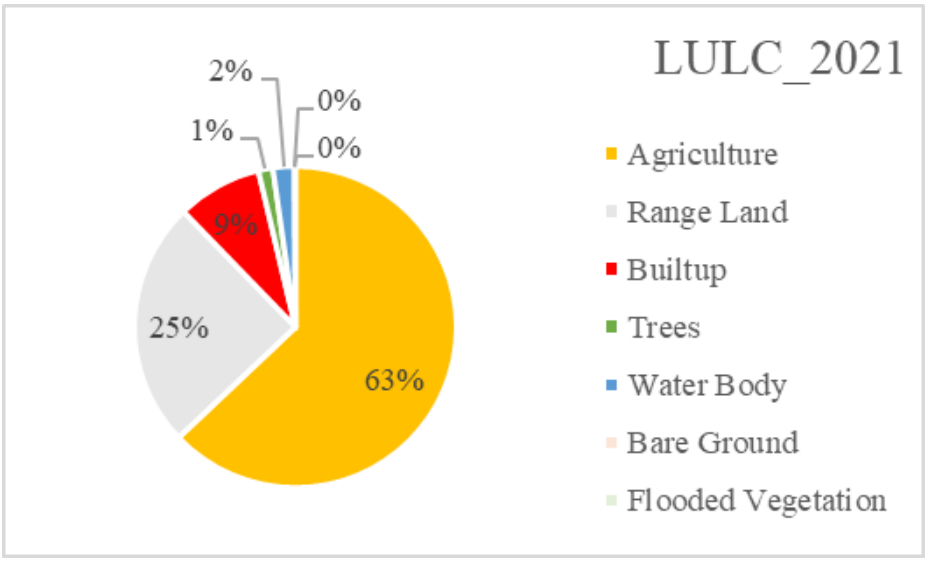

Fig. 13: LULC Analysis of Peri Urban Area of Mandal in 2021
Source: Primary data

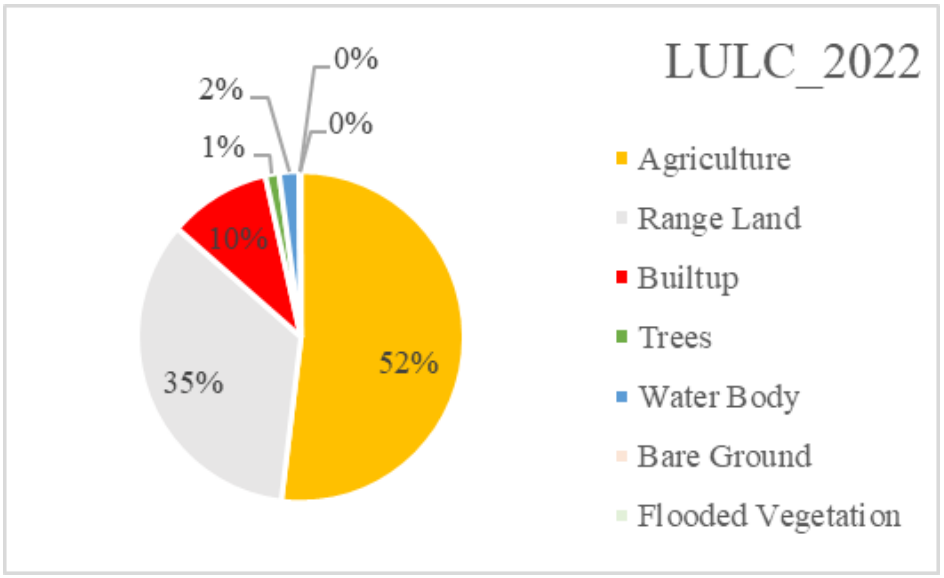

Fig. 14: LULC Analysis of Peri Urban Area of Mandal in 2022
Source: Primary data

Table 3: Accuracy Assessment results of 2022 LULC Map, Source: Primary data

ACCURACY ASSESSMENT OF LULC _2022 BIBI NAGAR PERI URBAN AREA							
LULC_CODE	**Agriculture**	**Bare Ground**	**Built up**	**Range land**	**Trees**	**Water body**	**Total (User)**
Agriculture	14	4	1	4	0	0	23
Bare Ground	0	1	0	0	0	0	1
Built up	0	0	37	0	0	0	37
Range land	0	1	2	15	0	0	18
Trees	6	1	0	0	13	0	20
Water body	0	0	0	0	0	11	11
Total (Producer)	20	7	40	19	13	11	110
Over Accuracy	82						
Kappa Coefficient	77						

Fig. 15: A: Agricultural land, B: Rangeland, C: Trees, D: Water Body E: Built up, F: Bare Ground
Source: Primary data

Table 4: Results of Change detection Analysis ,

S.No.	LULC_CODE	2017-2018 Changes(Sq.Km)	2018-2019 Changes(Sq.Km)	2019-2020 Changes(Sq.Km)	2020-2021 Changes(Sq.Km)	2021-2022 Changes(Sq.Km)
1	Agriculture	0.29	4.23	1.49	0.67	-6.64
2	Bare Ground	-0.02	-0.01	0	0.02	0.04
3	Builtup	0.15	0.2	0.72	0.05	0.97
4	Flooded Vegetation	0	0	0	0	0
5	Range Land	-0.57	-3.38	-3.38	-0.61	5.81
6	Trees	0.09	-0.9	1.16	-0.47	-0.06
7	Water Body	0.06	-0.13	0.28	0.33	-0.11

V. CONCLUSIONS

In conclusion, the present investigation was conducted in a rapidly developing peri-urban area situated in Telangana state, which is located in the region of South India. The analysis of Changes in the utilization and coverage of land over time within the designated region for examination or analysis. utilized remote sensing and GIS techniques, making use of multi-temporal satellite data. The findings indicate that agricultural land, including crop and plantation areas, is the primary land cover category in the peri-urban area of Bibi Nagar falling under the jurisdiction of Hyderabad Metropolitan Region. However, between 2017 and 2022, there has been a rise in range lands and built-up areas while agricultural lands and water bodies have experienced a decline during this period. These trends suggest that the development of commercial and infrastructure centers has had a negative impact on agricultural lands. Moreover, there has been an expansion of built-up areas at the expense of adjacent agricultural lands near townships. Ground-truth verification confirms that population growth and rapid economic development are significant factors driving this expansion of built-up land. The methodology employed in this study demonstrates the ability of remote sensing and GIS to analyze changes in land use/land cover for a given area. The results obtained from this research can be valuable for individuals in positions of authority in management and strategic decision-making sectors when it comes to implementing effective and sustainable management strategies.

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- Research and Development Cell- School of Planning &Architecture, JNA&FAU, Hyderabad, India

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