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Multi-Temporal Assessment Of Urban Land Use And Land Cover Change In Lb Nagar (2013–2024) Using Remote Sensing And Gis

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Abstract: In India, urbanisation and sustainable development are intricately linked. To measure the rate of urban growth and spatial transformations, Land Use and Land Cover (LULC) acts as an indicator. LB Nagar, the eastern zone locality of Hyderabad, has experienced rapid land conversion over the last decade. This research work analyses the pattern of land transformation in LB Nagar during the period of 2013-2024 with the help of remote sensing satellite and GIS. This research work is based upon an analytical framework. To analyse the spatio-temporal change more effectively, the time period for this study has been divided into three phases, i.e. 2013 to 2016, 2017 to 2020 and 2021 to 2024. Multispectral satellite images were captured by using open-source data such as USGS (United States Geological Survey) and the Landsat-8 satellite. All the satellite data of each time phase were processed and analysed by using supervised classification and change detection methods. The LULC of each time period were classified into different categories such as water body, dense vegetation, mixed open land, fallow urban land and built up. This research work explains the use of multi-temporal GIS-based analysis for understanding the urban growth and land use transformations. The analysis of this research work indicates a continuous increase of urban growth in LB Nagar across all three-time phases. The findings of this research work also provide important insights for decision makers and urban planners to regulate sustainable urban development and protect ecological spaces.

Index Terms - Land Use and Land Cover (LULC), Remote Sensing, Geographic Information System (GIS), Multi-Temporal Analysis, Urban Growth, LB Nagar.

I. INTRODUCTION

India is witnessing a rapid phase of socio-economic development. Urbanisation and land use transformation play a pivotal role in the development process of India. The rigorous development of residential buildings, transportation networks, and urban infrastructure has led to significant changes in land use and land cover (LULC) patterns [13, 7]. For sustainable urban growth, analysing these rapid changes is quite necessary, so that we can understand the spatial dynamics of urbanisation and can assess effective urban planning, which will not only support the urban growth but also secure the surrounding ecological impacts [18].

Hyderabad, the capital of Telangana, is one of the important metropolitan cities of India. Over the past two decades, the city of pearls has undergone an accelerated transformation in terms of population increase, economic development, and urban growth [11]. As the city has expanded from the core area to the outer area, several peripheral areas have also experienced rapid urban transformation. LB Nagar falls in the eastern part of Hyderabad. It represents a temporal variation in urbanisation, where intense developmental activities have reportedly changed land use patterns [15]. Over the time period, this area has witnessed dynamic morphological changes accompanied by the conversion of open spaces and vegetated areas into urban land uses. Such kind of process-driven changes have raised concerns related to environmental degradation, reduction of green cover, shrinking of water bodies, and asymmetric urban expansion [14].

In this research work, Geographic Information System (GIS) and Remote sensing techniques have played a linchpin role in analysing the rapid LULC transformations [9]. The analysis is also based on the data from the Landsat-8 satellite, which provides proficiencies for spatial analysis, mapping, and change detection [17]. The multispectral integration of these technologies enables a spectral evaluation of urban land use change dynamics and provides evidence-based decision-making [8]. In this research work, the time period has been taken from 2013 to 2024. This is because this particular time frame reflects recent socio-economic planning and rapid urbanisation in the study area [4]. To understand the urban growth progression more effectively, further the time period from 2013 to 2024 has been further divided into three different phases, i.e. 2013–2016,

2017–2020, and 2021–2024. This phase-wise analysis helps in identifying the distance, direction, and nature of land transformation over time [19].

Literature Review:

With the advent of liberalisation, privatisation and globalisation in the early 1990s, India has witnessed accelerated socio-economic growth in terms of population growth and infrastructure-led development in terms of rapid urbanisation [10]. Such kind of asymmetrical urban expansion has vigorously changed the land use and land cover pattern across all over India [16]. Various research works have proved that when urban growth is not fulfilling the criteria of sustainability, then it will impact the surrounding environment by converting water bodies, mixed open land, agricultural land and vegetation into built-up areas [1]. This also leads to numerous problems, such as poor air and water quality, environmental degradation, ecological imbalance, and high urban heat stress [12]. If we consider the 2011 census of India report, then we can realise that the urban population in India has hiked from 27.8% in 2001 to 31.2% in 2011, with metropolitan cities emerging as the epicentre for territorial expansion [3]. Therefore, analysis of land use and land cover patterns has become a typical approach to understand the rate of urban transformations [5].

Hyderabad, a strategic metropolitan city of India, has witnessed rapid urbanisation over the last two decades [2]. As per the findings of Greater Hyderabad Municipal Corporation (GHMC) and the Telangana State Statistical report, Hyderabad has experienced rapid radial expansion driven by IT sector development, macro-scale transport projects, and intensified real estate activity. Pioneer research works upon LULC and government planning documents of Hyderabad indicate that the eastern and southeastern side of the city has experienced significant land conversion over the last decade. The Hyderabad Metropolitan Development Authority (HMDA) has widely acknowledged various enduring challenges due to unplanned urban expansion, such as the decline of urban lakes, open spaces, and green cover [6]. Pursuant to the metropolitan regions of Hyderabad, LB Nagar is ideally appropriate for the study of LULC transformations and urban expansions. Its corridor-based location along National Highway no 65, metro rail connectivity, and proximity to major residential and commercial corridors have accelerated the urbanisation process. Therefore, LB Nagar becomes an ideal research work case study to analyse urban growth dynamics with the techniques of remote sensing and GIS, such as multi-spectral analysis of consistent and comparable satellite data.

Objectives:

1. To analyse the land use and land cover pattern of LB Nagar through phase-wise time period, i.e. 2013-2016, 2017-2020 and 2021-2024.
2. To assess the direction and nature of urban growth in LB Nagar during the time period of 2013-2024 by using Remote sensing and GIS techniques.

Study Area:

Lal Bahadur Nagar or LB Nagar is a major urban area that comes under the Saroornagar Mandal of Ranga Reddy district, within the limits of LB Nagar zone of Hyderabad, Telangana. Geographically, it is located at approximately 17.20° N to 17°23′ N latitude and 78°32′ E to 78°36′ E longitude. More specifically, it is located along the Hyderabad–Vijayawada corridor, i.e. Circle 3 of the East Zone of GHMC and serves as a major gateway connecting Hyderabad with eastern Telangana and coastal Andhra Pradesh. The area belongs to the Deccan Plateau and features gently undulating terrain with an average elevation of around 536 meters above sea level.

LB Nagar serves as an important residential, commercial, and transit hub in eastern Hyderabad. It is located along the Inner Ring Road and National Highway 65, making it a key junction that connects various industrial hubs such as Uppal and Nacharam. Administratively, it falls under Saroornagar Mandal, which is one of the prominent urban mandals in the district.

As per the 2011 Census, LB Nagar had a population of over 261,987, with a sex ratio of around 950 females per 1,000 males. The literacy rate is relatively high, estimated at around 74%, with male literacy at approximately 64% and female literacy around 52%. The urban nature of LB Nagar, combined with its strategic location and increasing population density, makes it a crucial site for analysing the impact of rapid urban growth. Figure 1 shows the location of the study area.

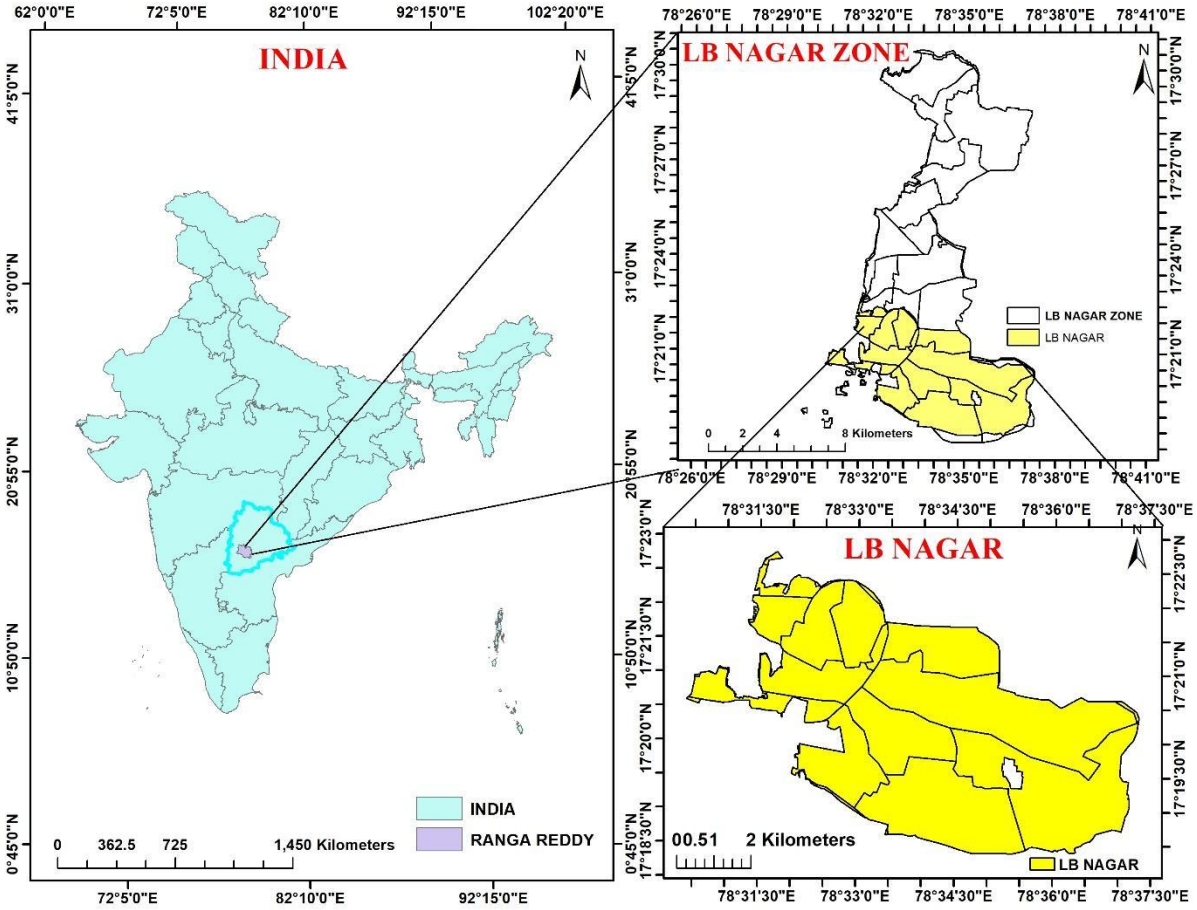


Figure 1. Location map of the study area
[Source: Generated by the author based on the Census of India, 2011]

II. Research Methodology:

This research work is completely based on applications and techniques of remote sensing and Geographical Information Systems (GIS). The research work follows a systematic methodology of satellite data acquisition, image processing, LULC classification, urban growth change detection, spatial analysis of urban growth direction, as well as distance and area calculation.

Data Collection:

Multispectral satellite data of LB Nagar for the time period of 2013-2024 were collected by using the USGS, i.e. United States Geological Survey platform. In this work, the Landsat-8 collection Level-2(C2 L2) images were used as they are both radiometrically and atmospherically corrected. Cloud cover was <8% was chosen to maintain proper data quality.

Data Analysis:

For this work, all the analyses were done using ArcGIS and MS Excel. Initially, all the satellite images were divided into three-time frames, i.e. 2013-206,2017-2020 and 2021-2024, and then for each time period, supervised classification was done along with area calculation for LULC change detection. Further, all three LULC maps were classified into features such as water bodies, dense vegetation, mixed open land, Fallow urban land and built-up area. After that, to detect overall urban growth from 2013 to 2024, all three time-period LULC maps were merged by using the combine tool of ArcGIS. To evaluate the spatial urban growth direction and spread, the Euclidean Direction tools in ArcGIS were employed. Finally, for the quantitative analysis of area change, graph preparation and comparison, MS Excel was used.

III. Discussion:

LULC Interpretation of LB Nagar from 2013-2016:

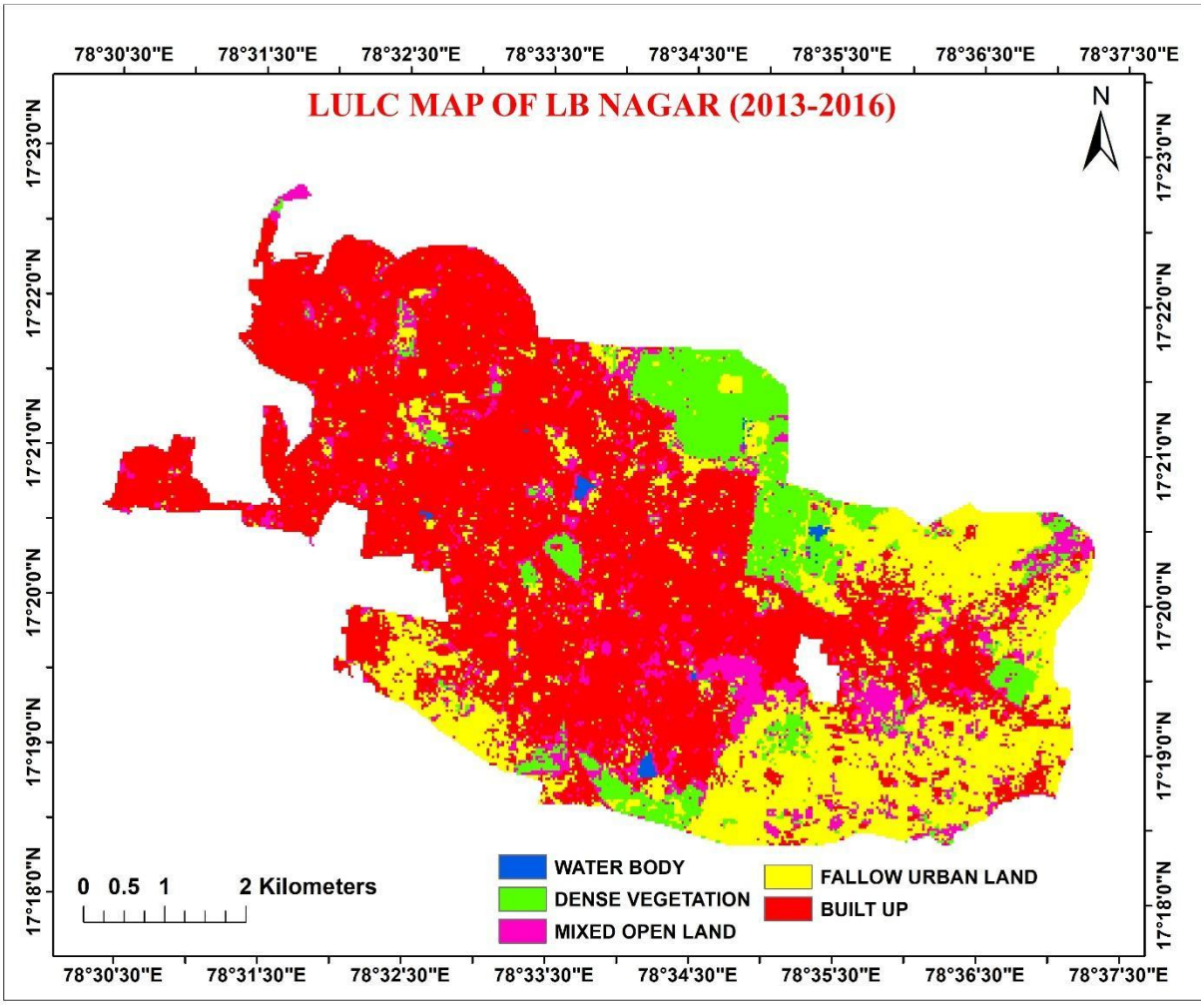


Figure 2. Land Use and Land Cover Pattern in LB Nagar During 2013-2016
[Source: Prepared by the Author using Landsat-8 C2 L2 data]

Table 1. LULC area statistics of LB Nagar (2013-2016)

LULC AREA 2013-2016		
FEATURES	**AREA(KM^2)**	**PERCENTAGE**
BUILT UP	**27.80474382**	**57.07713359**
DENSE VEGETATION	**4.719680796**	**9.688485284**
FALLOW URBAN LAND	**11.8612857**	**24.34865765**
MIXED OPEN LAND	**4.160080351**	**8.539746437**
WATER BODY	**0.168540398**	**0.345977035**

[Source: Calculated by the author using MS Excel and ArcGIS]

The Figure 2 and Table 1 represent the LULC pattern and area statistics of LB Nagar during the time period of 2013 to 2016. The above figure and table indicate that during 2013-2016, the LULC pattern of LB Nagar was clearly dominated by urban development. The central, western and north-eastern part of the area was completely dominated by built-up expansion, covering 27.80 km² (57.08%). The eastern and southeastern part of the area was extensively covered with fallow urban land, accounting for 11.86 km² (24.35%). These areas represent partially developed land, vacant plots and transitional built-up spaces. The southern, south-eastern marginal areas and fragmented patches in the north of the area have dense vegetation, covering 4.72 km² (9.69%). Mixed open lands are distributed in the north-eastern and eastern parts and cover 4.16 km² (8.54%). These features represent intermediate land use zones. Water bodies only cover 0.17 km² (0.35%). These are unevenly distributed and mostly appear in the southern and eastern parts of the study area.

LULC Interpretation of LB Nagar from 2017-2020:

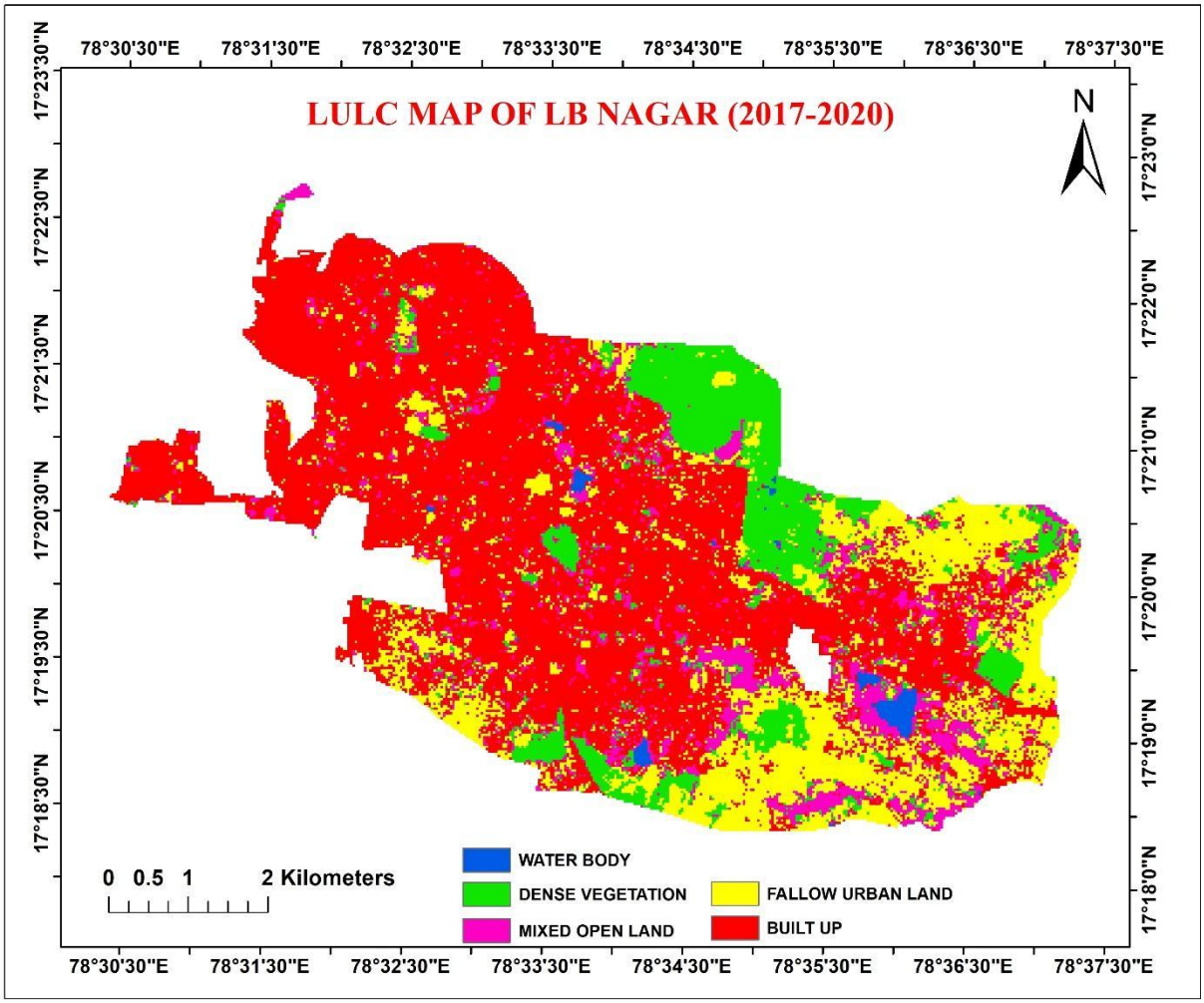


Figure 3. Land Use and Land Cover Pattern in LB Nagar During 2017-2020
[Source: Prepared by the Author using Landsat-8 C2 L2 data]

Table 2. LULC area statistics of LB Nagar (2017-2020)

LULC AREA 2017-2020		
FEATURES	**AREA(KM^2)**	**PERCENTAGE**
BUILT UP	**27.93292101**	**57.33785747**
DENSE VEGETATION	**5.839094459**	**11.98589885**
FALLOW URBAN LAND	**10.02919404**	**20.58690883**
MIXED OPEN LAND	**4.522230064**	**9.282773639**
WATER BODY	**0.392927322**	**0.806561218**

[Source: Calculated by the author using MS Excel and ArcGIS]

The Figure 3 and Table 2 represent the LULC pattern and area statistics of LB Nagar during the time period of 2017 to 2020. The above figure and table represent the continued dominance of urban development in LB Nagar during the time period of 2017-2020. As compared to the earlier time period, i.e. 2013-2016, built-up area, mixed open land and vegetation have shown a notable increase. Built-up land has expanded more and covers the central, western and north-western parts with a total area of 27.93 km² (57.34%). Similarly, vegetation is pronounced in the eastern and south-eastern part of the study area and accounts for 5.84 km² (11.99%), which is higher than the early time phase. Mixed open land occupies only 4.53 km² (9.28%) and is confined mainly along the southern fringe areas. On the other hand, fallow urban land and water bodies have faced a sharp decline. The area coverage of fallow urban land has reduced to 10.03 km² (20.59%), and it is now covering the south-eastern and southern parts. Water bodies are covering only 0.39 km² (0.81%), and just like the earlier phase, they are scattered in the form of isolated small pockets.

LULC Interpretation of LB Nagar from 2021-2024:

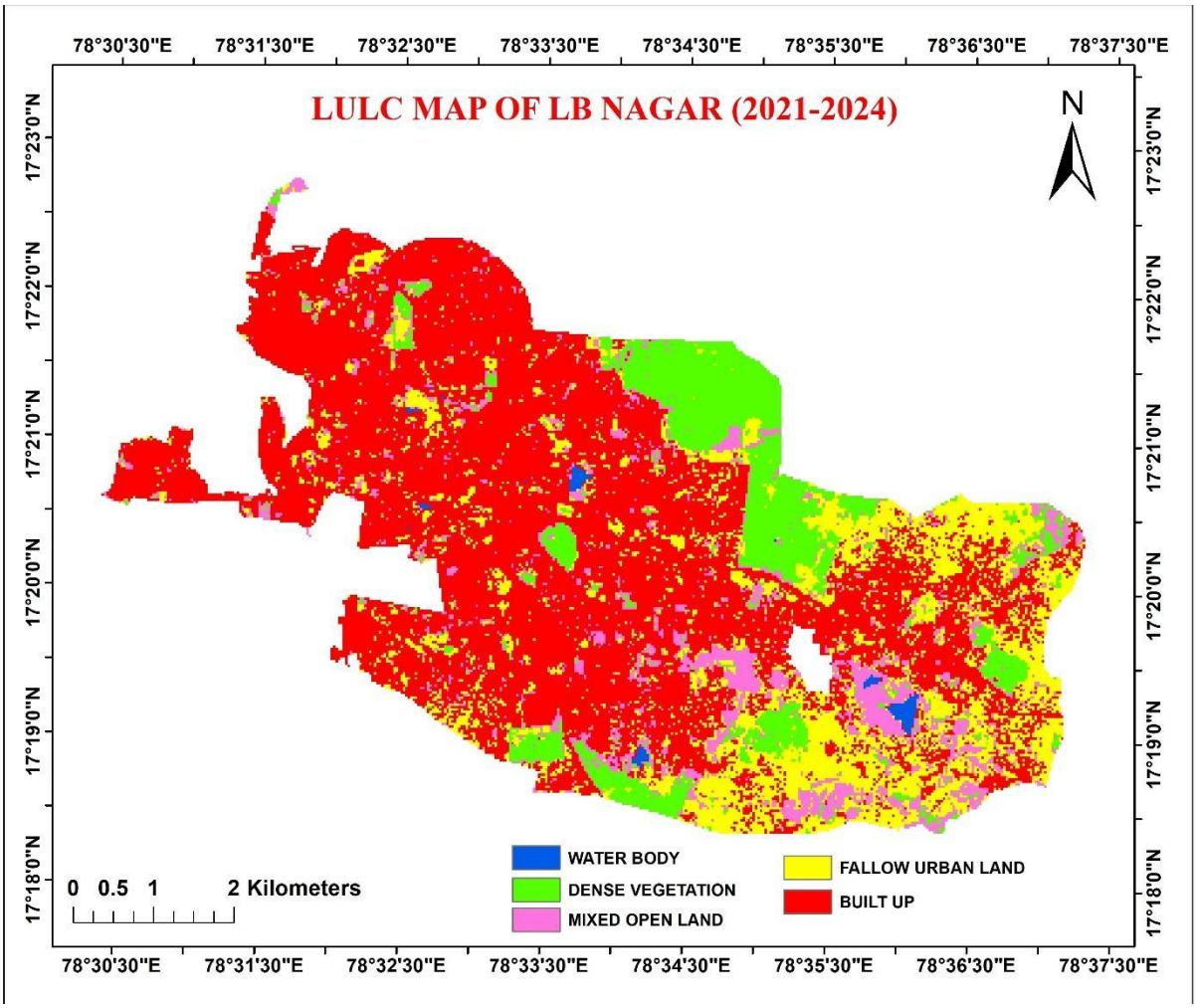


Figure 4. Land Use and Land Cover Pattern in LB Nagar During 2021-2024
[Source: Prepared by the Author using Landsat-8 C2 L2 data]

Table 3. LULC area statistics of LB Nagar (2021-2024)

LULC AREA 2021-2024		
FEATURES	**AREA(KM^2)**	**PERCENTAGE**
BUILT UP	**29.35846043**	**60.26376651**
DENSE VEGETATION	**5.645524337**	**11.58850142**
FALLOW URBAN LAND	**9.257381533**	**19.00251822**
MIXED OPEN LAND	**4.235644243**	**8.694457131**
WATER BODY	**0.219593368**	**0.450756724**

[Source: Calculated by the author using MS Excel and ArcGIS]

The Figure 4 and Table 3 represent the LULC pattern and area statistics of LB Nagar during the time period of 2017 to 2020. Analysis of the LULC map of 2021-2024 and table statistics reveals higher dominance of built-up area across the central, western and north-western parts of the study area. It covers 29.36 km² (60.26%) of the area, which is higher than the earlier time periods. It also reveals that urban expansion has become more significant and continuous. Dense vegetation occupies 5.65 km² (11.59%) of the area and appears more fragmented around the eastern and southeastern parts of the city. Though it has been reduced as compared to 2017-2020, but it's persistency is maintaining ecological balance against rapid urbanisation in LB Nagar. Fallow urban land occupies only 9.26 km² (19.00%) of the area, and if we compare it with earlier time frames, then we can notice it has faced a sharp decline throughout the time period. This sharp decline signifies the transformation of empty and transitional space into built-up areas. Mixed open land is still limited to southern fringe areas, and occupies 4.23 km² (8.69%) of the area. The reduction of water bodies from 0.39 km² (0.81%) in 2017-2020 to 0.21 km² (0.45%) in 2021-2024 highlights the rate of rapid urban growth and land transformation process in LB Nagar.

Total urban Growth and Land transformation (2013-2024)

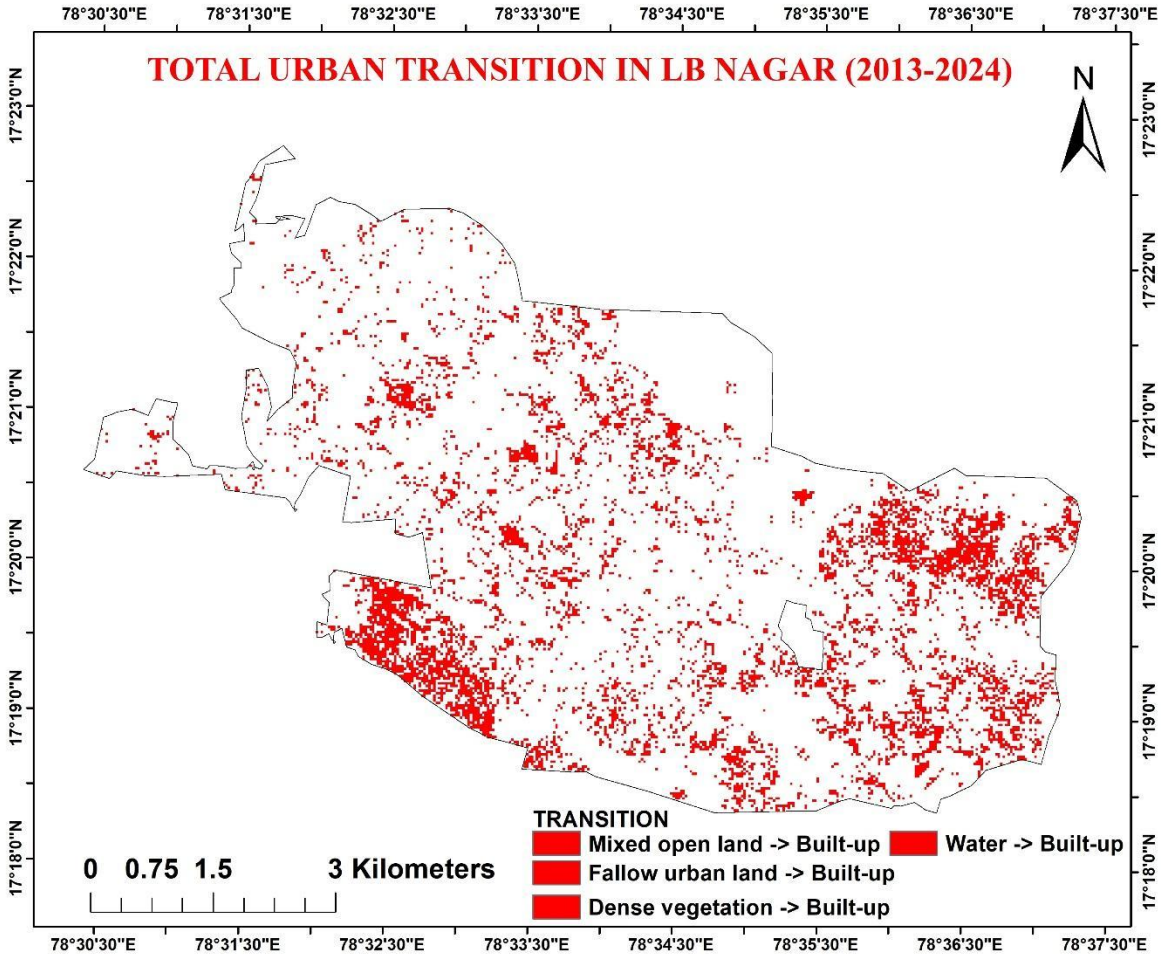


Figure 5. Total urban transition in LB Nagar During 2013-2024
[Source: Prepared by the Author using Landsat-8 C2 L2 data]

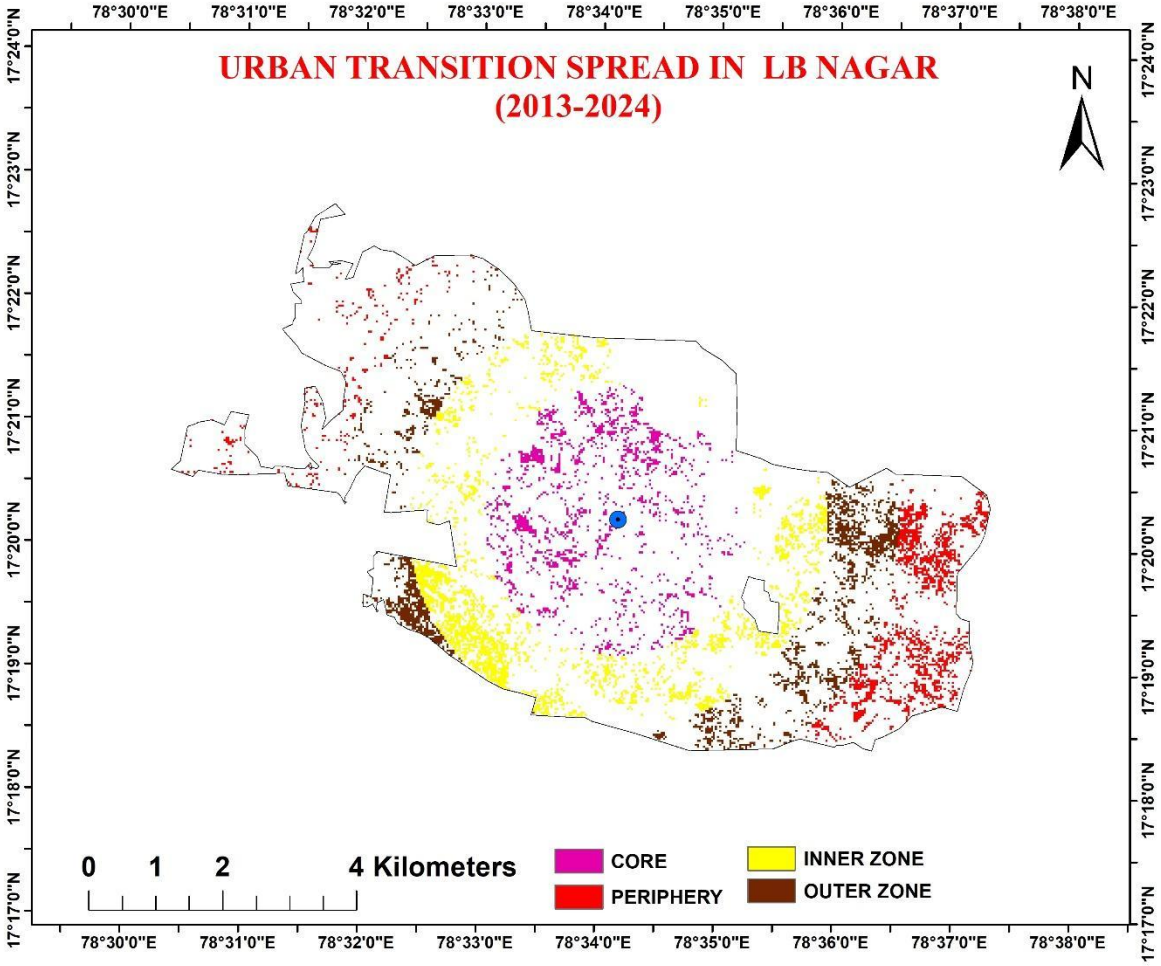


Figure 6. Urban growth spread in LB Nagar 2013-2024
[Source: Prepared by the Author using Landsat-8 C2 L2 data]

Table 3. Total urban growth area statistics in LB Nagar (2021-2024)

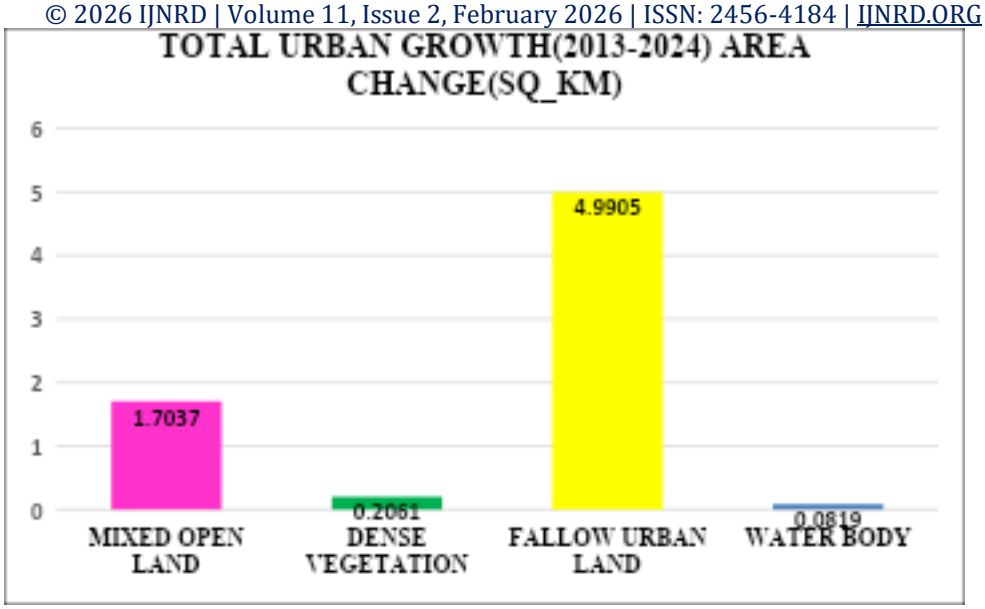
TOTAL URBAN GROWTH (2013-2024)		
FROM	**TO**	**AREA CHANGE(SQ_KM)**
MIXED OPEN LAND	**BUILT UP**	**1.7037**
DENSE VEGETATION	**BUILT UP**	**0.2061**
FALLOW URBAN LAND	**BUILT UP**	**4.9905**
WATER BODY	**BUILT UP**	**0.0819**

[Source: Calculated by the author using MS Excel and ArcGIS]

The Figure 5, Figure 6 and Table 4 represent the urban growth transformation analysis of LB Nagar from 2013-2024. The analysis indicates the transformation of non-built-up space to built -up areas. The Figure 5 also reveals that the urban growth transformation in LB Nagar is asymmetric in nature. From the data of Table 4 it is evident that the maximum conversion to urban growth has come from Fallow urban land i.e. 4.99 km². This signifies that fallow urban lands within the core and outer zones of LB Nagar are nothing but primary reserves for built-up landforms. When we observe closely, we can notice that this transformation has occurred in the eastern, southern and south-western part of the LB Nagar. This also indicates that urbanisation has a direction from core area to boundary areas as shown in Figure 6.

The total transformation of mixed open land into built-up area is 1.70 km². This indicates throughout 2013 to 2024, isolated and scattered mixed open lands of core areas are absorbed into urban fabric. This also indicates that urbanisation process in LB Nagar is more compact.

The conversion of water bodies and dense vegetation in LB Nagar into built-up areas are smaller in magnitude i.e. 0.08 km² and 0.21 km² respectively but this also highlights that the eastern and south-eastern inner zone areas are facing sheer ecological degradation pressure and urban encroachment. The graph 1 indicates the growth rate of various non-urban features inti built-up areas from 2013 to 2024.



Graph 1. Rate of urban growth change in LB Nagar (2013-2024)
[Source: Calculated by the author using MS Excel and ArcGIS]

Direction of urban Growth and Land transformation (2013-2024):

The Figure 7 and Table 3 reveal the directional deduction of urban growth in LB Nagar area from 2013 to 2024. It also reveals that the urban growth in LB Nagar has happened asymmetrically and it does not walk parallelly with sustainable development. From Figure 7 it is also evident that the urban growth in LB Nagar indicates strong direction biasness as high urban concentration has happened along the northern and south-western directions.

From the data of Table 3 it is also clear that highest urban growth has happened in the norther direction (25.13%) and then in the south-western direction (21.91%). This reflects significant urban expansion toward established residential and transport-linked zones. Then west direction of LB Nagar also reveals progressive lateral growth with growth rate 18.37%. if we combine all these three directional growth rates, then we can observe that total 65% of total urban growth rate has happened only in certain directions during the study period.

From the Figure 7 it is evident that the eastern and north eastern parts of LB Nagar have faced moderate urban growth rate with urbanisation rate 9.43% and 9.14% respectively. On the other hand, the north-eastern, south-eastern and southern part shows very limited urbanisation with growth rate 7.44%, 5.73% and 2.85% respectively.

Table 3. Total urban growth direction and area statistics in LB Nagar (2021-2024)

DIRECTION	AREA	PERCENTAGE
SOUTH WEST	1.7604	25.13169729
WEST	0.5211	7.439290762
NORTH WEST	0.6606	9.430810741
NORTH	0.4014	5.730438134
NORTH EAST	0.1998	2.852370551
EAST	1.5345	21.90671977
SOUTH EAST	1.287	18.37337787
SOUTH	0.6399	9.135294873

[Source: Calculated by the author using MS Excel and ArcGIS]

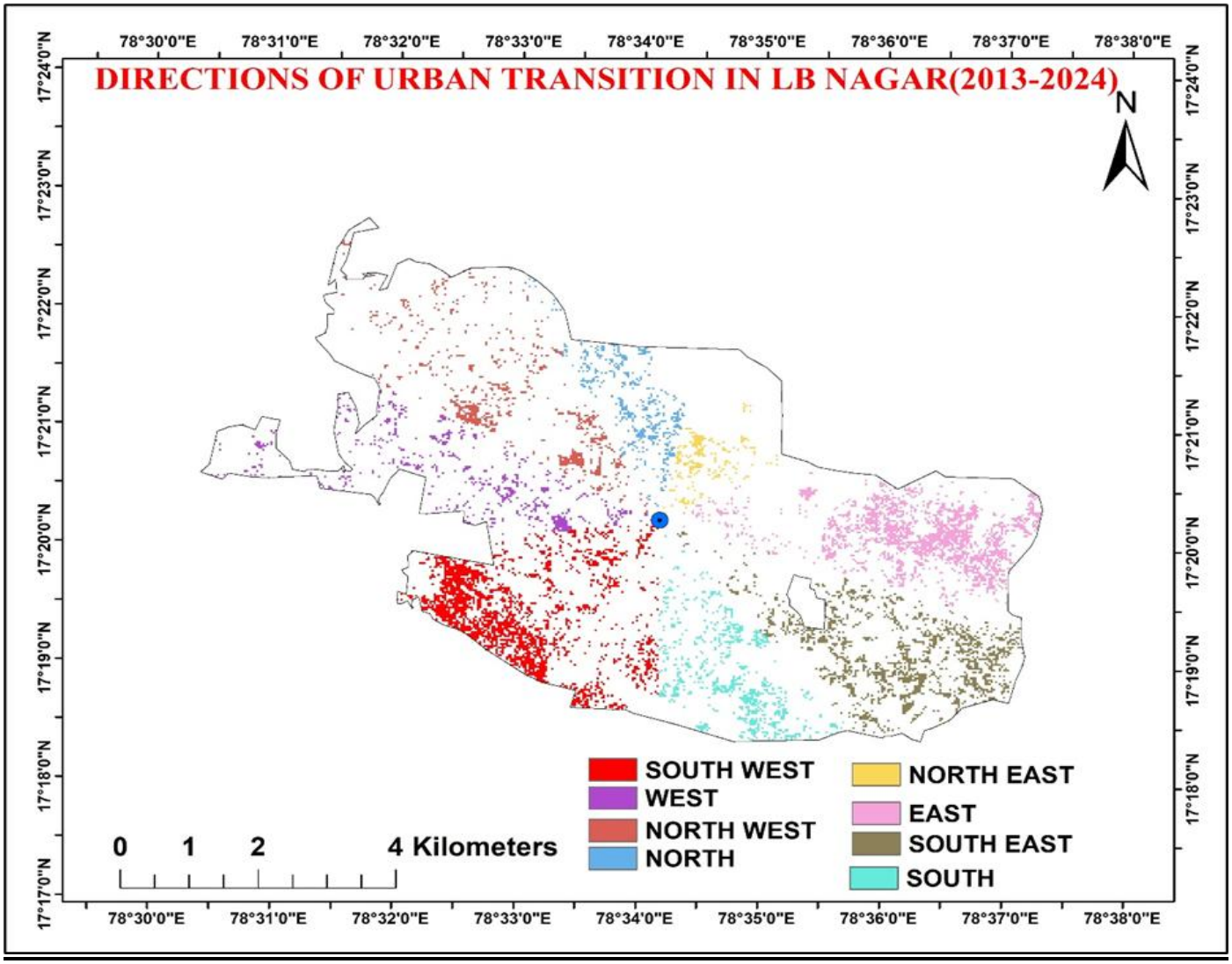
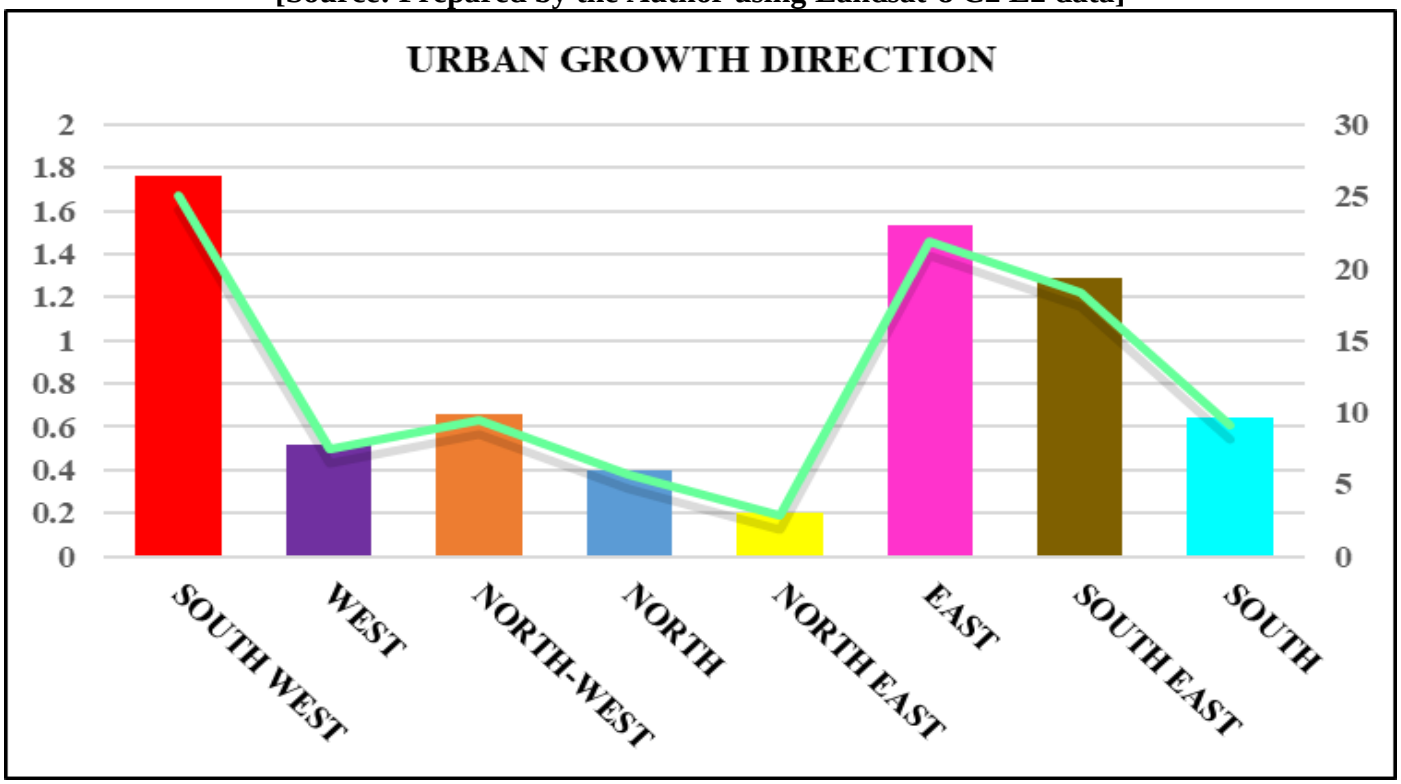


Figure 7. Urban growth direction in LB Nagar 2013-2024
[Source: Prepared by the Author using Landsat-8 C2 L2 data]



Graph 2. Urban growth direction in LB Nagar (2013-2024)
[Source: Calculated by the author using MS Excel and ArcGIS]

As shown in Graph 2, the directional analysis of urban growth rate in LB Nagar indicates that the urban expansion in LB Nagar exhibits sector-oriented growth pattern rather than uniform sustainable expansion.

IV. Conclusion:

This research work provides both qualitative and quantitative analysis of urban growth change dynamics with land use land cover change assessment of LB Nagar over the period 2013-2024 by using multi temporal techniques of remote sensing as well as GIS. The analysis of this research work clearly indicates that, the study area has undergone through asymmetrical urban transformation characterized with intensified urban growth rate, reduction of open spaces and advancement of spatial consolidation.

The early phase i.e. 2013-2016 indicates the coexistence of high urban built-up and fallow urban land, which covering maximum area of the LB Nagar. This period was also characterized by high urban stress as the total area covered with vegetation and water bodies were limited. Overall, this time period sets the stage for subsequent urban growth.

The middle age of urbanisation in LB Nagar i.e. 2017-2020 indicates that the land transformation process has shifted from expansion-oriented growth to densification of urban growth. Though this phase has witnessed increase in urban vegetation but the urbanisation pattern was more about compacted urban fabric form.

The last stage of urban growth in LB Nagar i.e. 2021-2024 indicates an intensified urbanisation patten where built-up land alone exceeds more than 60% of total area and significant marginalization of non-built-up spaces such as water bodies and vegetation. In this phase maximum spaces of fallow urban land and mixed open land have converted to built-up areas and sustainable urban development continued to decline. This highlights the cumulative ecological impact of long-term unplanned urbanisation.

The directional and spread analysis of urban growth in LB Nagar also highlight that the urbanisation phenomena in LB Nagar throughout the time period of 2013 to 2024 is more about sector oriented, where dominant urban growth has happened in the north, west and south-west direction. Overall, the research work concludes that, over the time period of 2013 to 2024 LB Nagar has transformed into an urban corridor which has been influenced by density driven and directional biased development process. To ensure sustainable development and to avoid ecological degradation the findings of this research work suggest strategies such as corridor-based urban planning, protection of open and ecological spaces with regulated urban desertification.

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