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REMOTE SENSING-BASED HEAT RISK MAPPING TO SUPPORT CLIMATE RESPONSIVE ZONING AND URBAN RESILIENCE STRATEGIES IN LB NAGAR (2013-2024)

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Abstract: Rapid urban growth has exacerbated surface thermal stress in LB Nagar, Hyderabad, increasing susceptibility to heat-related disasters. Land Use/Land Cover (LULC), Land Surface Temperature (LST), Urban Heat Island Index (UHI), and geographical patterns of urban expansion are integrated to analyze thermal dynamics from 2013 to 2024. Multi-temporal Landsat data were utilized to get land surface temperature (LST) and categorize land use and land cover (LULC) changes. To evaluate thermal anomalies Urban heat island (UHI) index was computed by which heat intensity zones and transition maps were prepared. These maps show those regions which were once open land, vegetation, and water bodies were present are now converted to impermeable built-up areas. The developed areas, especially primary transportation routes and adjacent regions exhibited very high land surface temperatures and urban heat island classifications in the results. Higher Land Surface temperatures and proliferation of impermeable surface show that they are directly proportional in high temperature clusters. Those Regions which undergo transformation from dense vegetation and mixed open land to developed areas consistently align with the rise of thermal hotspots. The research aims to devise spatial decision-support system for disaster risk mitigation by integrating land modification activities with temperature indices. There are strategic solutions to incorporate heat sensitive zoning into urban planning, expansion of green infrastructure, establishment of blue-green corridors, and implementation of regulated urban densification techniques to inculcate climate responsive urban design and aim for long term urban resilience in LB Nagar.

***Index Terms* -** Land surface temperature, Urban heat island, Thermal hotspots, Climate responsive Urban planning, Disaster Risk Reduction.

1. INTRODUCTION:

In rapidly expanding peri urban zones such as LB Nagar which is located in eastern corridor of Hyderabad there is transformational force called urbanization shaping metropolitan landscapes in India [3]. The observation over the decade shows that LB Nagar experienced residential expansion, transportation infrastructure development and commercial intensification. This growth contributes to economic development and improves connectivity at the same time leading to changes in urban microclimate by substituting natural land cover with impervious built-up regions [4][6]. The consequence is disruption in surface energy balance, reduction in evapotranspiration and intensified thermal stress which eventually results in urban heat island effect.

Heat risk assessments have become need of the hour as there is increase in frequency of extreme heat events across Indian cities. This urban heat affects outdoor thermal comfort causing increase in energy demand, public health vulnerability and disaster risk particularly among lower socio-economic populations [6]. Geospatial technologies and remote sensing provide strong framework for capturing land transformation and thermal consequences [1]. NASA United States Geological Survey Landsat missions provide with multi temporal satellite datasets which enable to derive Land Surface Temperature and Land Use/Land Cover dynamics over extended time periods [3].

There is integration of LULC classification, LST and Urban Heat Island Index in this study to analyses spatial patterns of urban expansion to evaluate thermal dynamics in study area between 2013-2024 [2] . This study tries to establish a direct relationship between land transformation and thermal intensity rise by mapping heat intensity zones and identifying how vegetated land is turned into impervious surfaces [4]. There is more emphasis on primary transportation corridors and high built-up clusters as they exhibit high intensity heat zones [3].

The overall aim is to develop spatial decision support framework that links land transformation changes to climate responsive urban planning strategies [6]. Identifying emerging thermal hotspots and vulnerable zones, the study gives evidence-based interventions such as heat sensitive zoning regulations, urban green infrastructure expansion, protection of remnant water bodies and development of blue green corridors. Long term urban resilience and climate adaptive planning in LB Nagar which aligns with geospatial analysis with sustainable urban governance are the major goals that can be focused upon using this study.

1.1. LITERATURE REVIEW:

Intense Urbanization has led to increased thermal characterization of the cities which consequently led to Urban heat Island phenomenon. This phenomenon shows urban areas experience higher temperatures than surrounding rural areas due to replacement of natural surfaces with impervious surfaces which include asphalt, concrete [5][8]. UHI effect is closely related to changes in Land Use/Land Cover [9][10]. The decline in vegetation and open land in rapidly urbanizing areas is also one of the suitable factors for formation of urban heat island [9].

To analyses urban thermal environments, remote sensing and geospatial technologies are the fundamental tools [5][8][9]. With the help of satellite imagery continuous monitoring of spatial and temporal variations in land surface temperatures are quantified [9]. The technologies help in studying large scale datasets that support urban climate studies to map heat intensity zones across metropolitan areas [10].

Studies highlighted strong relationship between LULC and LST patterns [9][10]. Lower albedo and limited evapotranspiration capacity is the primary reason for higher LST values in built up areas and transportation infrastructure [5]. Whereas vegetated and water bodies act like cooling elements within urban regions [10]. Studies across various cities proved that for increase in thermal hotspots and localized microclimate variations, urban expansion and land cover transformation are key drivers [9][10].

Contemporary research focusses on integration of thermal analysis with urban planning and climate adaptation strategies. GIS-RS based heat risk assessment maps can lead city planners to adopt climate responsive zoning, plan green infrastructure and include urban resilience strategies. Incorporation of vegetation corridors, protection of urban water bodies and regulation of high-density development can mitigate urban heat effects [7].

This existing literature with remote sensing-based assessment by integrating LST LULC and UHI intensity gives strong framework for analyzing relationship between urbanization and temperature rise [9][10]. This heat risk mapping helps in climate responsive planning strategies and strengthens urban resilience in the present era of climate change [7].

1.2. OBJECTIVE:

1. To generalize the Land use and land cover (LULC) and LST pattern in LB Nagar from 2013 to 2024.
2. To analyze the urban heat intensity pattern in LB Nagar from 2013-2024 in order to identify major heat-risk zones within the city.

1.3. STUDY AREA:

LB Nagar is a major peri- urban area which comes under the Saroornagar Mandal of Ranga Reddy district of 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 in the Circle 3 of the East Zone of GHMC and serves as a major gateway connecting Hyderabad with eastern Telangana. The area has 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. 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 analyzing the impact of rapid urban growth. Figure 1 shows the location of the study area.

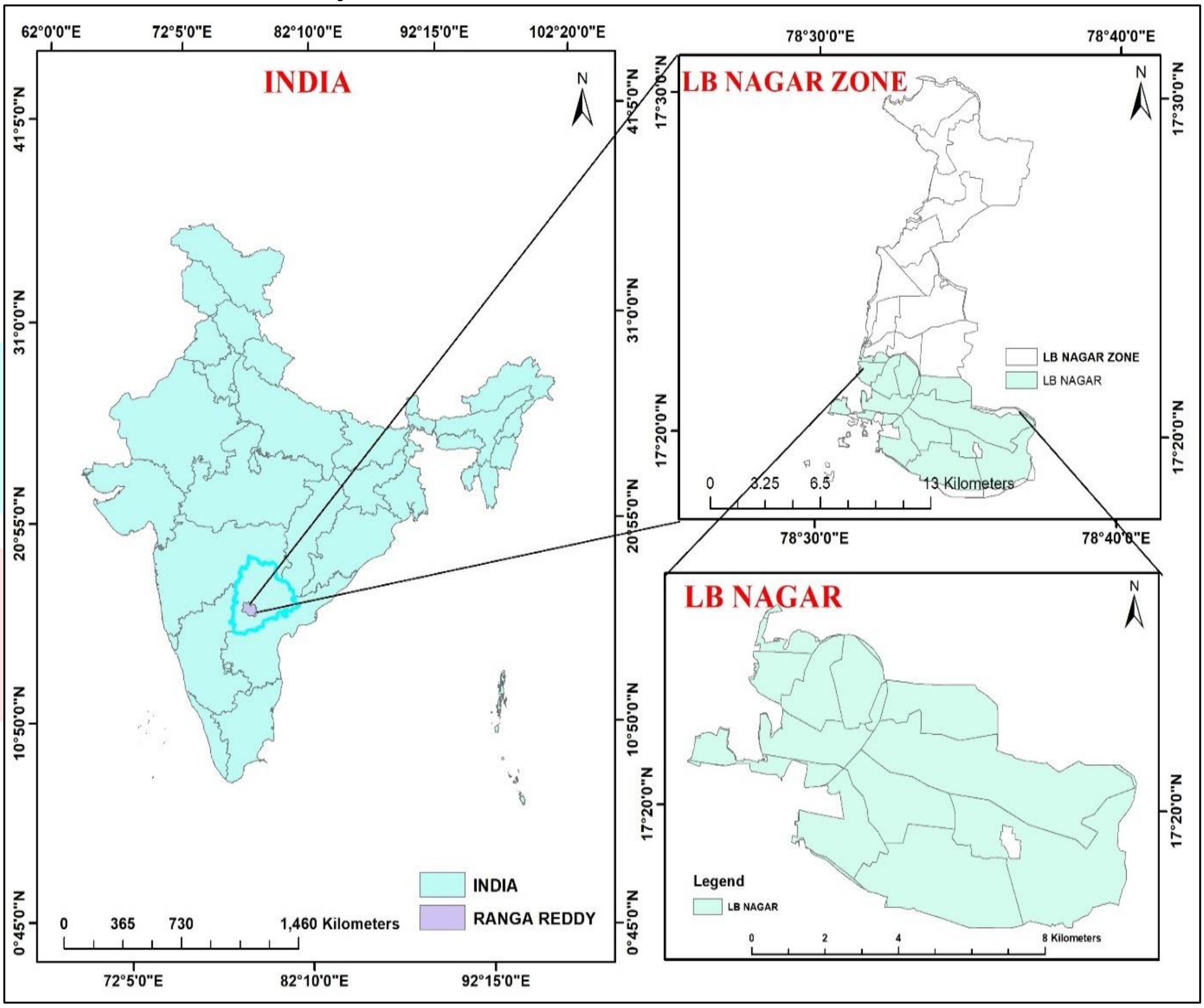

Figure 1 Location map of the study area
(Source: Prepared by the author by using census 2011 data and Arc-GIS tool)

2. RESEARCH METHODOLOGY:

This research study is completely based on applications and techniques of remote sensing. The research work follows a systematic methodology of satellite data acquisition, image processing, LULC classification, LST calculation and urban heat island change detection.

2.1. 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 L1 and C2 L2 images were used. Cloud cover was <10% was chosen to maintain proper data quality.

2.2. Data Analysis: For this work, all the analyses were done using ArcGIS and MS Excel.

2.2.1. LULC Calculation:

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.

2.2.2. LST Calculation:

For the LST calculation, first all the required parameters such as TOA, BT, NDVI, PV and LSE were calculated for the three time periods and then the LST for each time period was calculated by using the formula shown in Eq. (1).

$$\boldsymbol{LST = (BT)/(1 + (\lambda \times BT/c2) \times \ln(E))} \tag{1}$$

Where, λ = wave length emitted Radiance by Band 10 of Landsat 8 i.e. 10.8 and $c2$= 14388µmK or 14388 * 10^{-2}. The h (Planck's constant) = 6.626×10^{-34} J·s, k or S (Boltzmann constant) = 1.381×10^{-23} J/K and c (Speed of light in vacuum) = 2.998×10^{8} m/s.

2.2.3. Urban Heat Index calculation: The UHI Index of LB Nagar for the three time periods were calculated by using formula shown Eq. (2).

$$\boldsymbol{\frac{LSTi - LSTmin}{LSTmax - LSTmin}} \tag{2}$$

Then all the values are generalized and tables were created by using MS-Excel tool.

3. DISCUSSION:

<u>3.1. Spatial Distribution of Land Use and Land Cover (LULC) And Land Surface Temperature (LST) Zone in LB Nagar (2013-2024):</u>

3.1.1. Time Period 2013-2016:

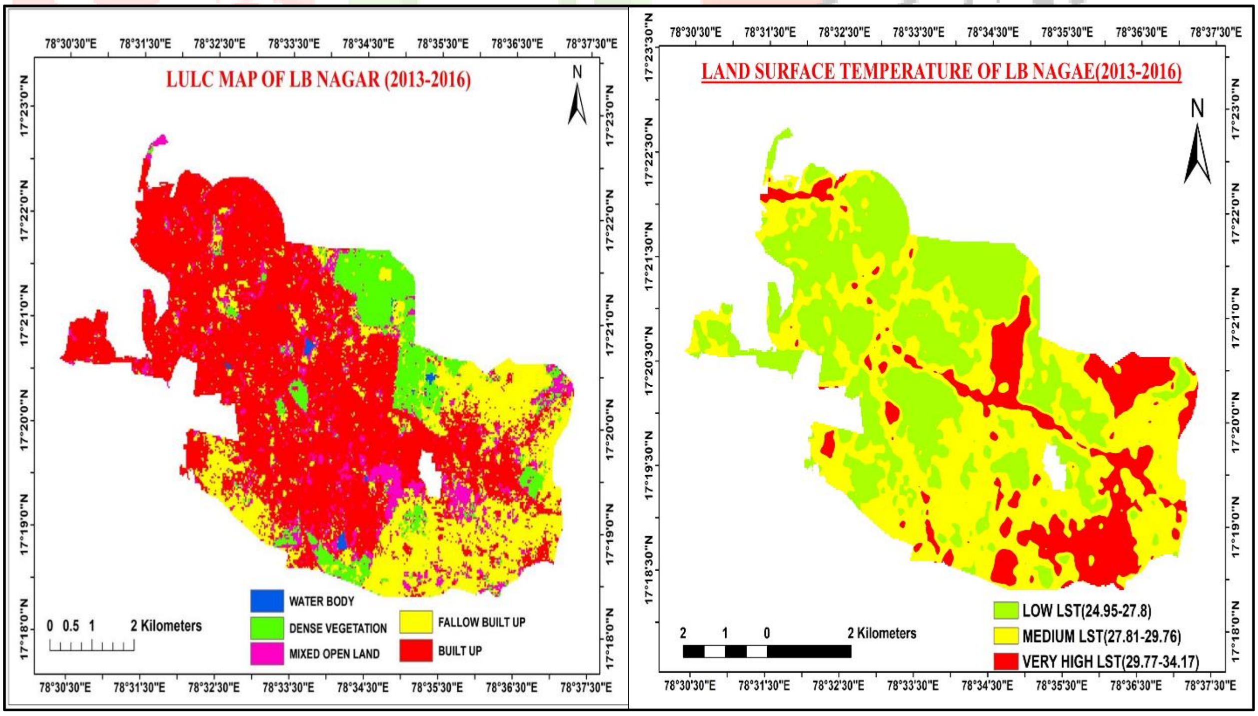

Figure 2 LULC and LST map of LB Nagar (2013-2016)
(Source: Generated by the author using Landsat 8 OLI/TIRS satellite and spatial analysis in ArcGIS)

Table 1 LULC and LST area distribution in LB Nagar (2013-2016)

LULC AREA 2013-2016		
FEATURES	**AREA(SQ_KM))**	**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**
LST IN LB NAGAR (2013-2016)		
FEATURES	**AREA(SQ_KM))**	**PERCENTAGE**
LOW LST	**18.7416**	**38.458271**
MEDIUM LST	**22.1562**	**45.46512272**
VERY HIGH LST	**7.8345**	**16.07660628**

(Source: Calculated by the Author using MS -Excel and Arc-GIS tool)

The Figure 2 and the area distribution data of Table 1 reveal an integrated relationship between LULC and LST of LB Nagar during 2013-2016. From the Figure 2 and Table 1 it is clear that, during 2013-2016, LB Nagar was a dense settlement zone as the built-up concentration was 57.08% and the fellow urban land concentration was 24.35%. This means, nearly 81% of the total area was under the influence of transitional urban spaces. Due to such kind of substantial control by the impervious surfaces, the LB Nagar during 2013-2016 was markedly influenced by high thermal pattern edges as 61.54% of the LB Nagar was falling under medium to very high LST zone. The central, western and north-western parts of the LB Nagar demonstrate strong clustering of built-up areas. These zones are creating LST zones and strong fields of high heat accumulation. The south-eastern and south-western parts of the LB Nagar exhibit zones of fallow urban land (24.34%). These zones are exhibiting emerging thermal hotspots and heat intensification zones. The eastern and the north-eastern margins show the existence of fragmented dense vegetation areas (9.69%). These zones are very close to low LST zones (38.46%), so these zones are the cooling zones which are created by the process of evapotranspiration. The water body is very limited as it covers only 0.35% of the total area. This further decreases the city's natural thermal buffering capacity. During 2013-2016, the LST ranged from high 34.17 °C to low 24.95 °C. This spatial gradient of temperature reveals that the accumulation of heat concentration was strongest in south-eastern, western and central urban axis while lowest in the eastern and north-eastern part of the city.

3.1.2. Time Period 2017-2020:

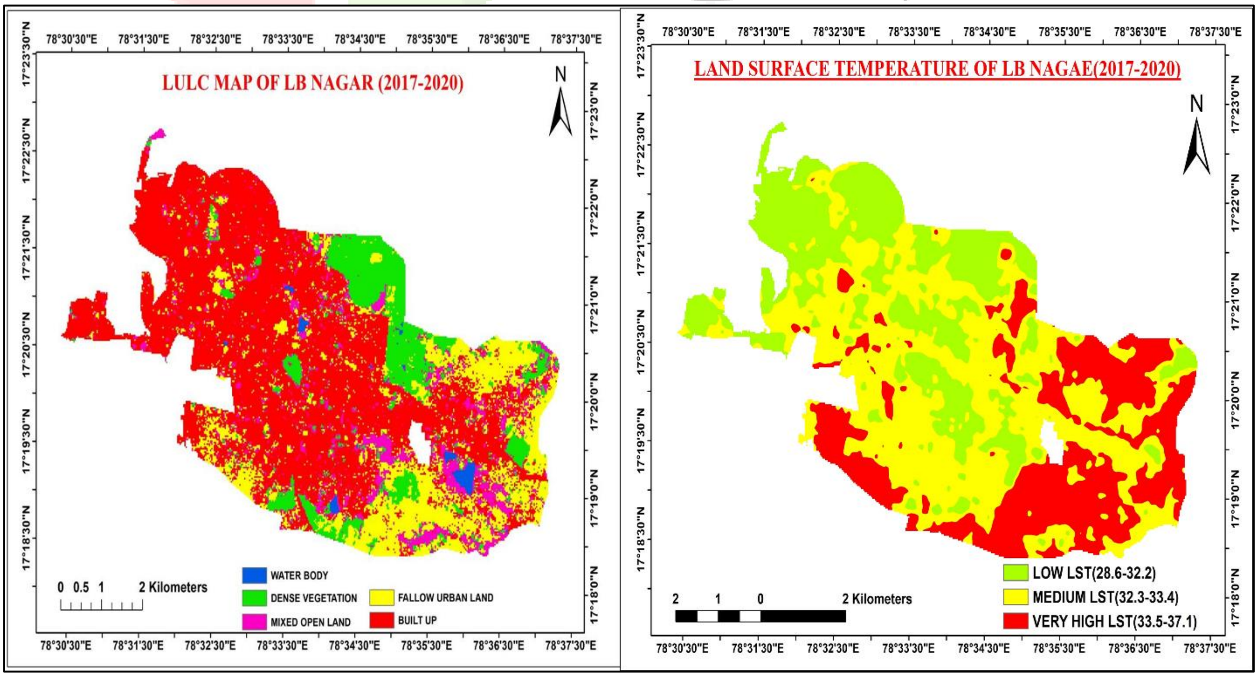

Figure 3 LULC and LST map of LB Nagar (2017-2020)
(Source: Generated by the author using Landsat 8 OLI/TIRS satellite and spatial analysis in ArcGIS)

Table 2 LULC and LST area distribution in LB Nagar (2017-2020)

LULC AREA 2017-2020		
FEATURES	**AREA(SQ_KM)**	**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**
LST IN LB NAGAR (2017-2020)		
FEATURES	**AREA(SQ_KM))**	**PERCENTAGE**
LOW LST	**13.9806**	**28.68857**
MEDIUM LST	**21.8664**	**44.87044527**
VERY HIGH LST	**12.8853**	**26.44098473**

(Source: Calculated by the Author using MS -Excel and Arc-GIS tool)

The Figure 3 and the area statistics from Table 2 reveal notable structural and thermal transformation of LB Nagar during the time period of 2017-2020. As compared to the year 2013-2016, the portion of built-up coverage in LB Nagar has been increased from 57.08% to 57.34% in 2017 -2020. This consolidation has been happened mostly in the western, central and north-western part of the city. On the contrary, the portion of fallow urban land has been decreased 24.35% to 20.59%. This implies with the passage of time, fallow urban land has been undergone the built-up transformation process. This reduction has also intensified surface sealing. On the other hand, the eastern and the north-eastern part of the city reflect spatial heterogeneity as the dense vegetation portion has increased from 9.69% to 11.99% and water body has also increased from 0.35% to 0.81%. The LST range of LB Nagar during 2017-2020 is from 37.1 °C to 28.6 °C. This indicates that, as compared to 2013-2016 a major thermal shift has happened and more than 1/4th of the city has also fallen under high temperature induced stress conditions. The very high LST zone has been increased from 16.08% to 26.445 and low LST zone has been decreased from 38.465 to 28.69%. this indicates that with the increase in built up area coverage, the cooling pockets within the urban area has been reduced. Although the medium LST zones are stable, but most of these parts are slowly moving towards the high LST zones. Overall, in 2017-2020, the temperature gradient has become more steeper as compared to 2013-2016 and the direction of heat accumulation has expanded towards south and south-east directions.

3.1.3. Time Period 2021-2024:

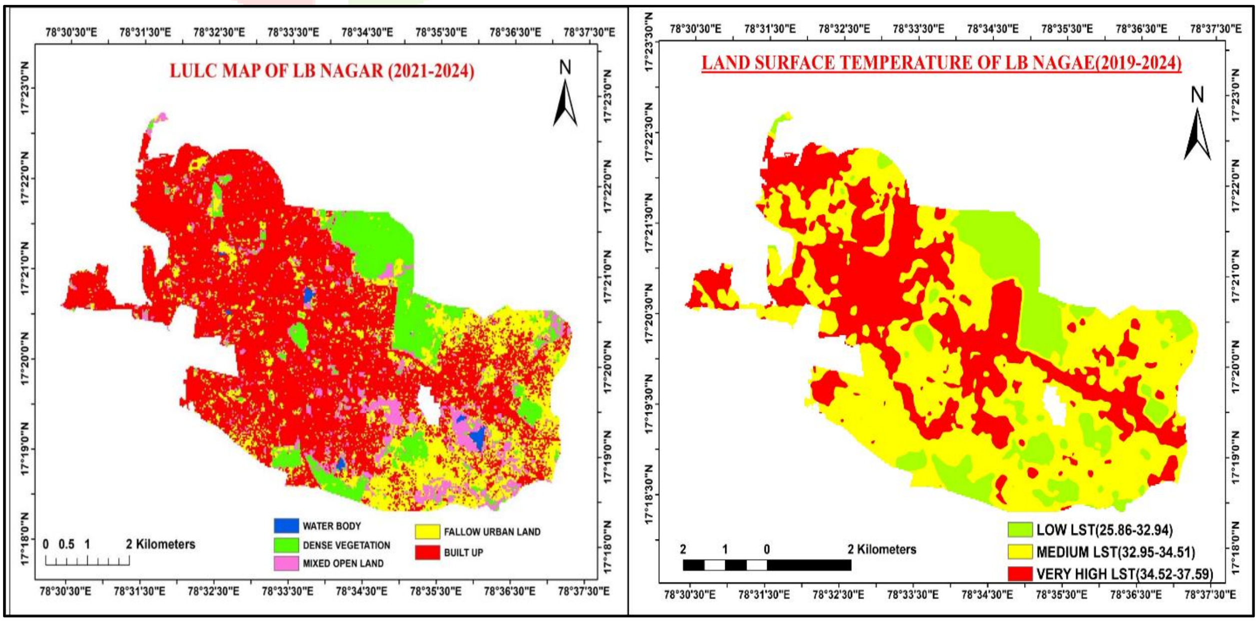

Figure 4 LULC and LST map of LB Nagar (2021-2024)
(Source: Generated by the author using Landsat 8 OLI/TIRS satellite and spatial analysis in ArcGIS)

Table 3 LULC and LST area distribution in LB Nagar (2021-2024)

LULC AREA 2021-2024		
FEATURES	AREA(SQ_KM)	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
LST IN LB NAGAR (2021-2024)		
FEATURES	AREA(SQ_KM))	PERCENTAGE
LOW LST	7.137	14.64531738
MEDIUM LST	16.3872	33.62697841
VERY HIGH LST	25.2081	51.72770421

(Source: Calculated by the Author using MS -Excel and Arc-GIS tool)

The spatial pattern demonstrated in Figure 4 and quantitative area data in Table 3, jointly reveal the final accelerated phase of urban expansion and thermal stress in LB Nagar during the time period of 2021-2024. As compared to 2017-2020, built-up in LB Nagar during 2021-2024 has increased from 57.34% to 60.26%. From Table 3 it is evident that except built-up other features have faced sharp reduction as compared to 2017-2020. The continuous reduction in fallow urban land (19%) and mixed open land (8.69%) indicates phase of accelerated urban transformation. On the other hand, the natural thermal cooling shield of the city has also been compromised as the water bodies (0.45%) and dense vegetation (11.8%) have also faced sharp reduction as compared to 2017-2020. During this time period, the central, western and north-western parts reflect intense urbanization and create a strong temperature core typified with very high LST clusters. The LST of LB Nagar during this time period ranges from high 37.5 °C to low 25.86 °C. This indicates the urban heat concentration in LB Nagar have become more territorially integrated. The very high LST zones and low LST zones are covering 51.72% and 14.64% of the total area of the city. High LST zones have covered the major directions of the city and cooling zones have restricted to mainly north-eastern margins.

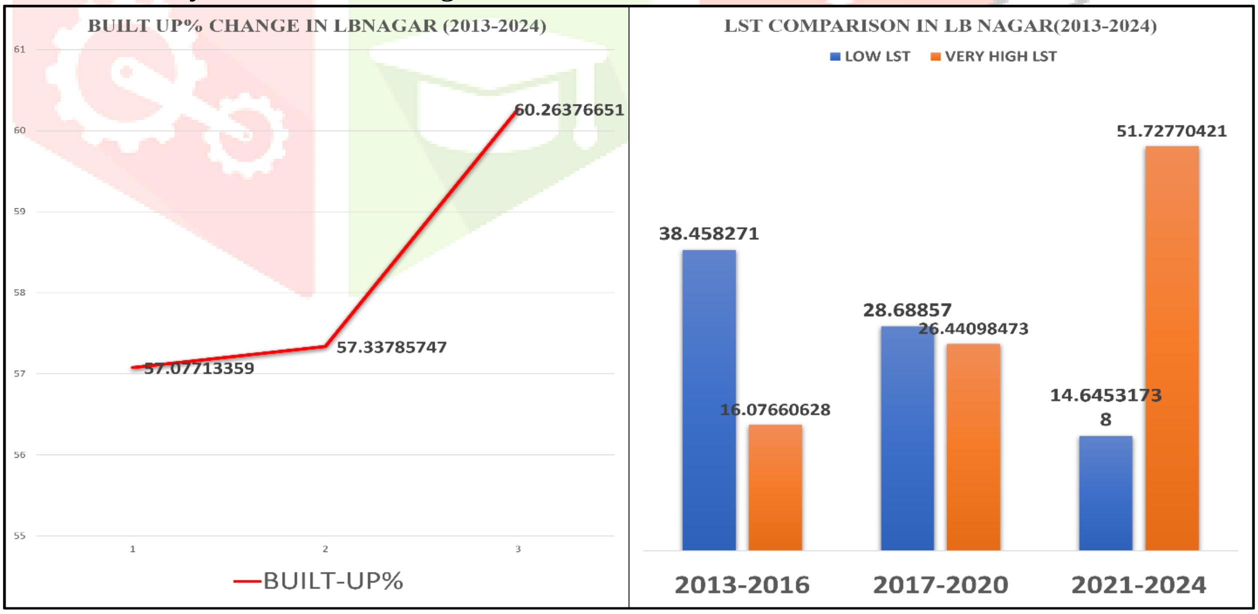

Figure 5 Built-up and Very high LST change in LB Nagar (2013-2024)
(Source: Prepared by the Author using data of Table 1, Table 2 and Table 3)

3.2. Analysis of Urban Heat Island effect and Built-up intensity in LB Nagar (2013-2024):

3.2.1. Time Period 2013-2016:

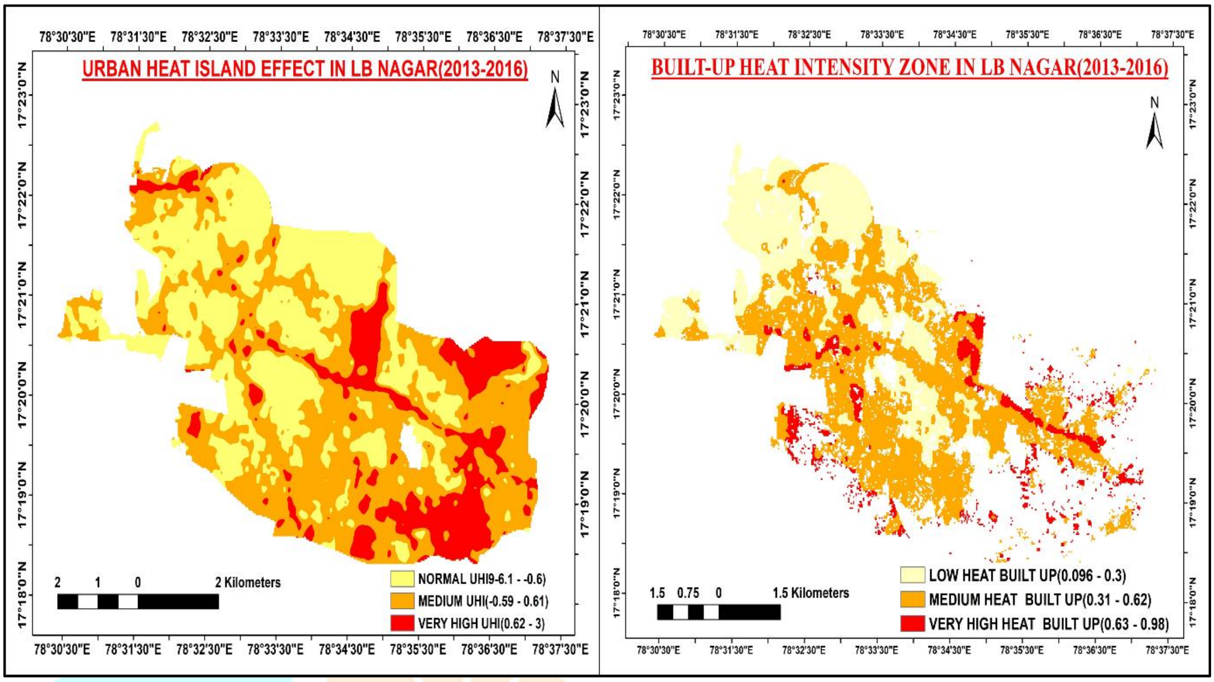

Figure 6 Urban Heat Island and Built-Up Heat Intensity Map of LB Nagar (2013–2016) (Source: Generated by the author using Landsat 8 OLI/TIRS satellite and spatial analysis in ArcGIS)

The Figure 6 represents the spatial variability of thermal intensity across the built-up portions in LB Nagar during 2013-2016. In this time period the Urban heat island effect ranges from high 3 °C to low -0.61 °C. This wide heat gradient emphasizes intra-metropolitan heat heterogeneity during 2013-2016. The map reveals that most of the very high UHI zones (0.62-3 °C) are concentrated in the southern, south-western and central axis of the city. These zones are full of high impervious surface covers and here evapotranspiration process is limited. On the other hand, normal or low UHI zones (–0.6 to –0.61 °C) are concentrated in the eastern and north-eastern part of the city. During this time period maximum part of the city are falling under medium UHI zones (–0.59 to 0.61 °C). The built-up thermal intensity values of LB Nagar during 2013-2016 ranges from 0.096 °C to 0.98 °C. Th south-eastern, central axis and southern part have very high heat built-up intensity zones ranging from 0.63 °C to 0.98 °C. These zones are also falling under the very high UHI zones. This reflects the fact that built-up intensity and heat concentration are the key determinants of elevated urban heat island effect. The western and the eastern part are showing medium heat built-up intensity (0.31 °C to 0.62 °C) while the northern, north-eastern and north-western parts are showing low heat built-up intensity zones (0.096 °C to 0.3 °C). Here, the medium and low heat built-up zones are indicating slow rise of consolidated thermal hotspots in LB Nagar during 2013-2016.

3.2.2. Time Period 2017-2020:

The Figure 7 demonstrates the thermal fluctuation across the built-up environment in LB Nagar during 2017-2020. In this time frame the Urban heat island effect ranges from high 3.7 °C to low -3.1 °C, which is very high as compared to 2013-2016 time period. This huge heat anomaly reveals the built-up heat variability during 2017-2020. During 2017-2020, the very high UHI zones (0.44 to 3.7 °C) are mostly concentrated in the southern, south-eastern and central axis parts of the city. As compared to 2013-2016, these zones have extended and covered more parts of city. Due to this, thermal retention and heat accumulation are significantly higher in these parts. On the contrary, just like 2013-2016 time period, the low UHI zones (–3.1 to –1 °C) are still concentrated in the eastern and north-eastern part of the city. But in this time period, moderate portion of the city are falling under medium UHI zones (–0.9 to 0.43 °C). The built-up thermal intensity values of LB Nagar during 2017-2020 ranges from 0.02 °C to 1 °C. The south-eastern, central axis and southern corridors have very high heat built-up intensity zones ranging from 0.54 °C to 1 °C. In the south-eastern part, the very high heat built-up intensity is more clustered where as in other part it is displaying fragmented pattern. The noticeable change in this time period is the rise of very high heat built-up intensity zone in a slight north portion of the city. This reflects the fact that built-up intensity and heat concentration around LB Nagar in 2017-2020 have been increased as compared to 2013-2016 and so as the urban heat island effect. Most of the western and the south-western part are showing medium heat built-up intensity (0.22 to 0.53 °C) while the northern, north-eastern and north-western parts are reflecting low heat built-up intensity zones (0.02 to 0.21 °C).

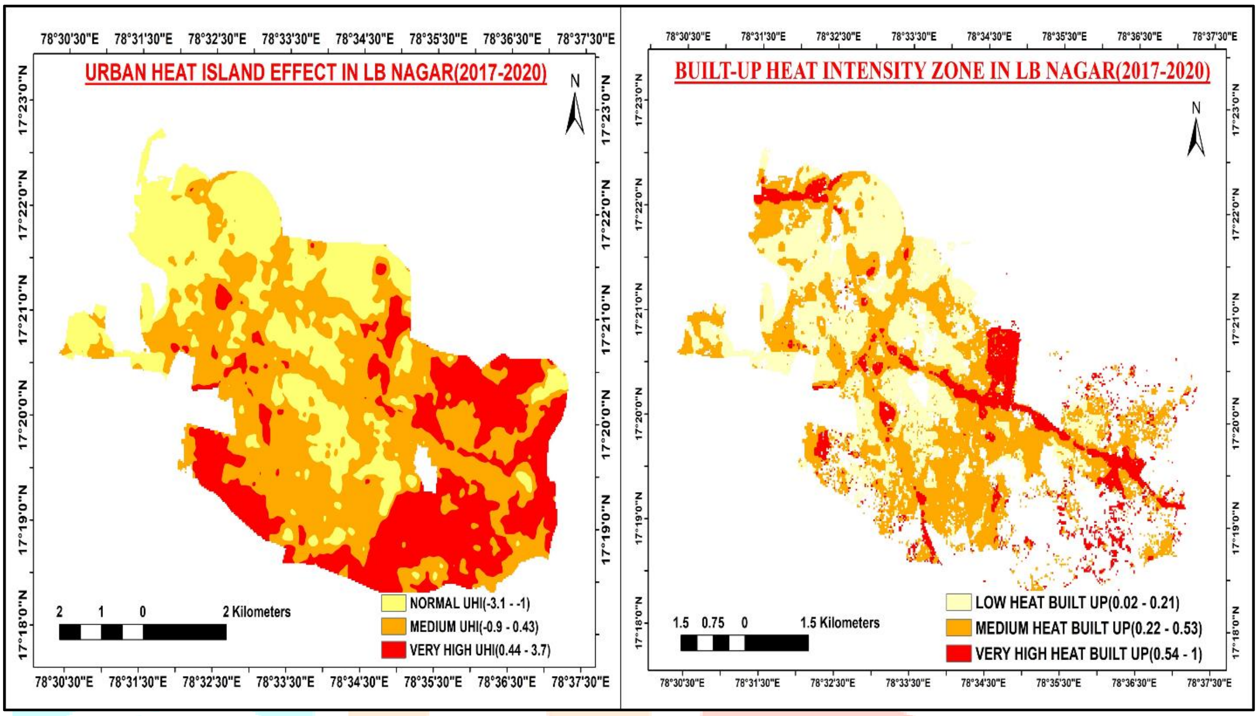

Figure 7 Urban Heat Island and Built-Up Heat Intensity Map of LB Nagar (2017–2020) (Source: Generated by the author using Landsat 8 OLI/TIRS satellite and spatial analysis in ArcGIS)

3.2.3. Time Period 2021-2024:

The Figure 8 indicates the thermal distribution across the urban environment in LB Nagar during 2021-2024. In this time frame the Urban heat island effect ranges from high 5.2 °C to low -4.6 °C, which is significantly high as compared to 2013-2016 and 2017-2020 time period. This substantial heat anomaly reveals the amplification of built-up heat intensity during 2021-2024. Though in previous time periods the UHI and heat built-up intensity effects were progressive but they were contained. In 2021-2024 time period, very high UHI zones (0.93 to 5.2 °C) have expanded significantly in the southern and south-eastern directions. These zones are also covering the central axis, western and south-western parts of the city. Due to this LB Nagar is having more pronounced and consolidated high-temperature intensity regions in this time period. This is also reflecting the strengthening of the thermal gradient as the heat intensity has increased from maximum of 3.7 °C in 2017-2020 to 5.2 °C in 2021-2024. The medium and low LST zones have become more fragmented and confined to limited pockets.

In 2021-2024, the very high heat built-up intensity zones (0.901 °C to 1.03 °C) have expanded in both geographical extent and cohesiveness. Most of the part of the city is now reflecting compacted very high heat built-up intensity zones where as medium and low heat built-up zones have become more fragmented. The central, eastern, western and northern parts are displaying more highly intensified thermal built-up. Areas which were under medium to low heat built-up intensity zones have transformed to very high heat built-up intensity zones. This period is also showing subsequent growth of thermal hotspots in the northward and southward directions.

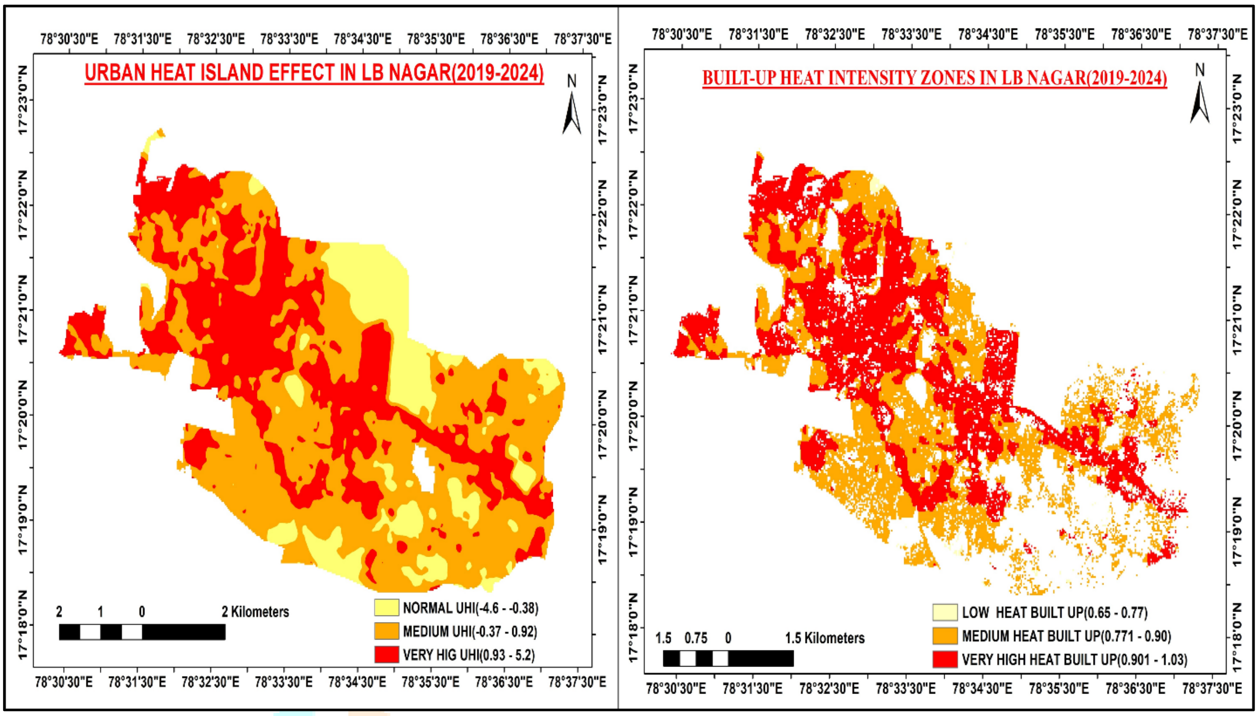

Figure 8 Urban Heat Island and Built-Up Heat Intensity Map of LB Nagar (2021–2024) (Source: Generated by the author using Landsat 8 OLI/TIRS satellite and spatial analysis in ArcGIS)

3.3. Spatio temporal consolidation of Very High UHI and Very High built-up intensity zones in LB Nagar (2013-2024):

The Table 4, Table 5, Figure 9 and Figure 10 demonstrate the consolidation of very high UHI zones and very high built-up intensity in LB Nagar from 2013 to 2024. This quantitative analysis reveals subsequent transition in both urban environmental extent and heat configuration. This analysis also reveals intensification of thermal stress pockets over time. As we can observe, the area under low heat built -up intensity has been decreased over the time, while the area under medium to very high heat built-up intensity has been quantitatively increased from 2013-2024. During 2013-2016, the area of very high heat intensity around the built-up area was very limited i.e. 7.137 SQ_KM. But in 2017-2020, the area of very high intensity was 13.2567 SQ_KM. This reveals that the 2017-2020 has experienced accelerated heat accumulation around the built-up expansion. However, the subsequent built-up growth happened in the year of 2021-2024. Here the extent is more than doubled as compared to the previous period. This also indicates the fact that, over the passage of time urban thermal stress has become sharp with the process of rapid urbanization.

The spatial pattern of heat intensity around the built-up environment of LB Nagar has also been evolved from isolated and random thermal pockets clustered and continuous. As we can notice from Figure 9 in 2013-2016, the zones were scattered and thermal retention was very low. However, in 2017-2020, the built-up compactness in the southern and south-eastern part of the city became more clustered. This is because in 2017-2020, the built-up density has increased as compared to the previous year and all the patches stated to merge. This transformation is reflecting the advancement of built-up surface coverage and decline of natural urban cooling capacity. But in 2021-2024, the heat intensity around the built-up areas became more pronounced and took a morphological turn. The built-up areas became spatially dominant and therefore the thermal corridors around the central, south-eastern and southern parts became more extensive.

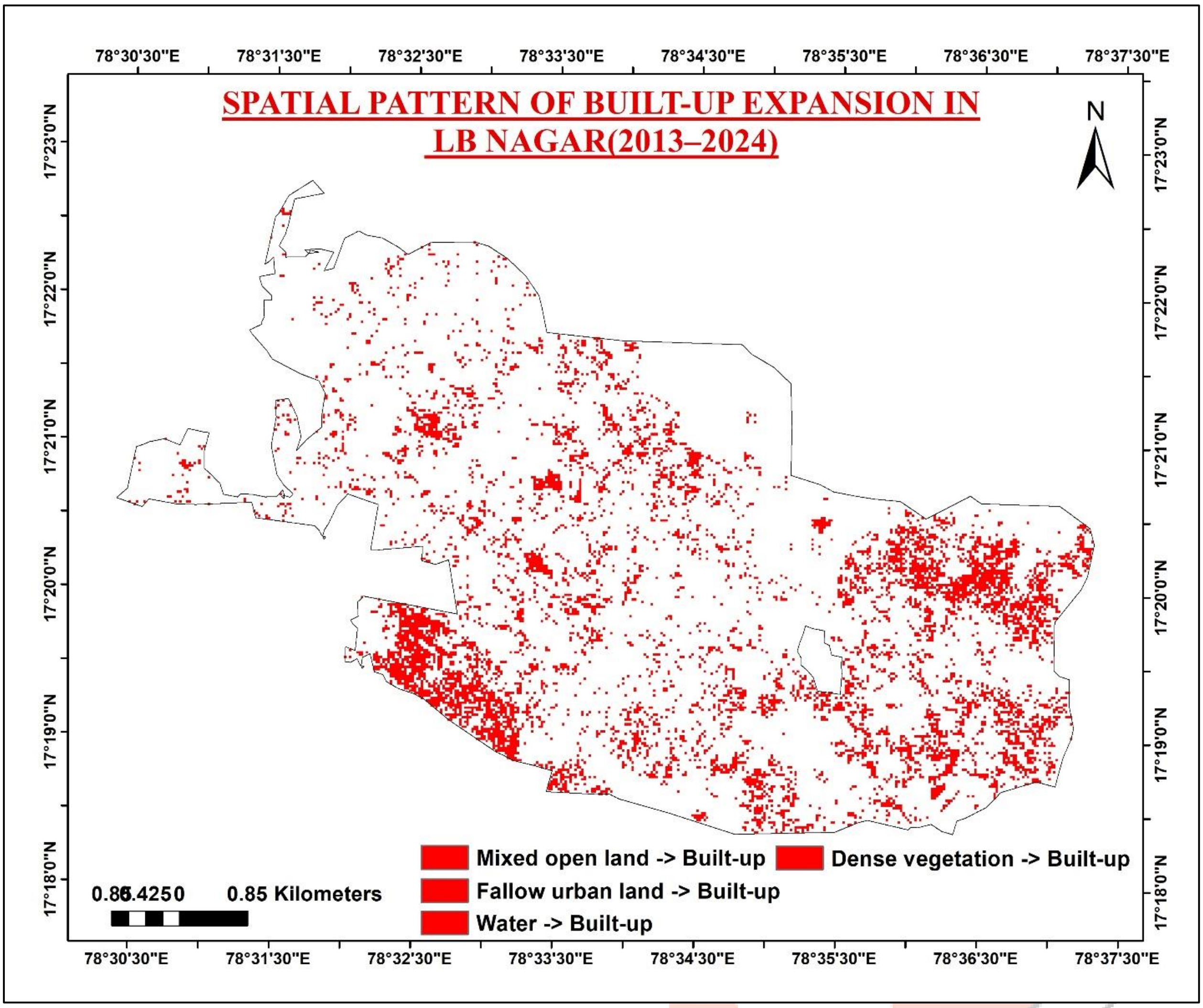

Figure 9 Spatial Pattern of Built-up Expansion in LB Nagar (2013–2024)
(Source: Generated by the author using Landsat 8 OLI/TIRS satellite and spatial analysis in ArcGIS)

Table 4 Total Urban growth change in LB Nagar (2013-2024)

FROM	TO	AREA CHANGE(SQ_KM)
MIXED OPEN LAND	BUILT UP	1.7037
MIXED OPEN LAND	FALLOW URBAN LAND	1.818
DENSE VEGETATION	MIXED OPEN LAND	0.9801
DENSE VEGETATION	FALLOW URBAN LAND	0.7902
DENSE VEGETATION	BUILT UP	0.2061
FALLOW URBAN LAND	BUILT UP	4.9905
WATER BODY	BUILT UP	0.0819
WATER BODY	FALLOW URBAN LAND	0.0306
WATER BODY	MIXED OPEN LAND	0.1359

(Source: Prepared by the Author using MS -Excel and Arc-GIS tool)

Table 5 Area Statistics of Heat Built-up Intensity in LB Nagar (2013-2024)

YEAR	LOW HEAT BUILT-UP INTENSITY	MEDIUM HEAT BUILT-UP INTENSITY	VERY HIGH HEAT BUILT-UP INTENSITY
	AREA(SQ_KM)	AREA(SQ_KM)	AREA(SQ_KM)
2013-2016	18.7416	13.9806	7.137
2017-2020	22.1562	16.3872	13.2567
2021-2024	7.8345	18.3645	28.3386

(Source: Prepared by the Author using MS -Excel and Arc-GIS tool)

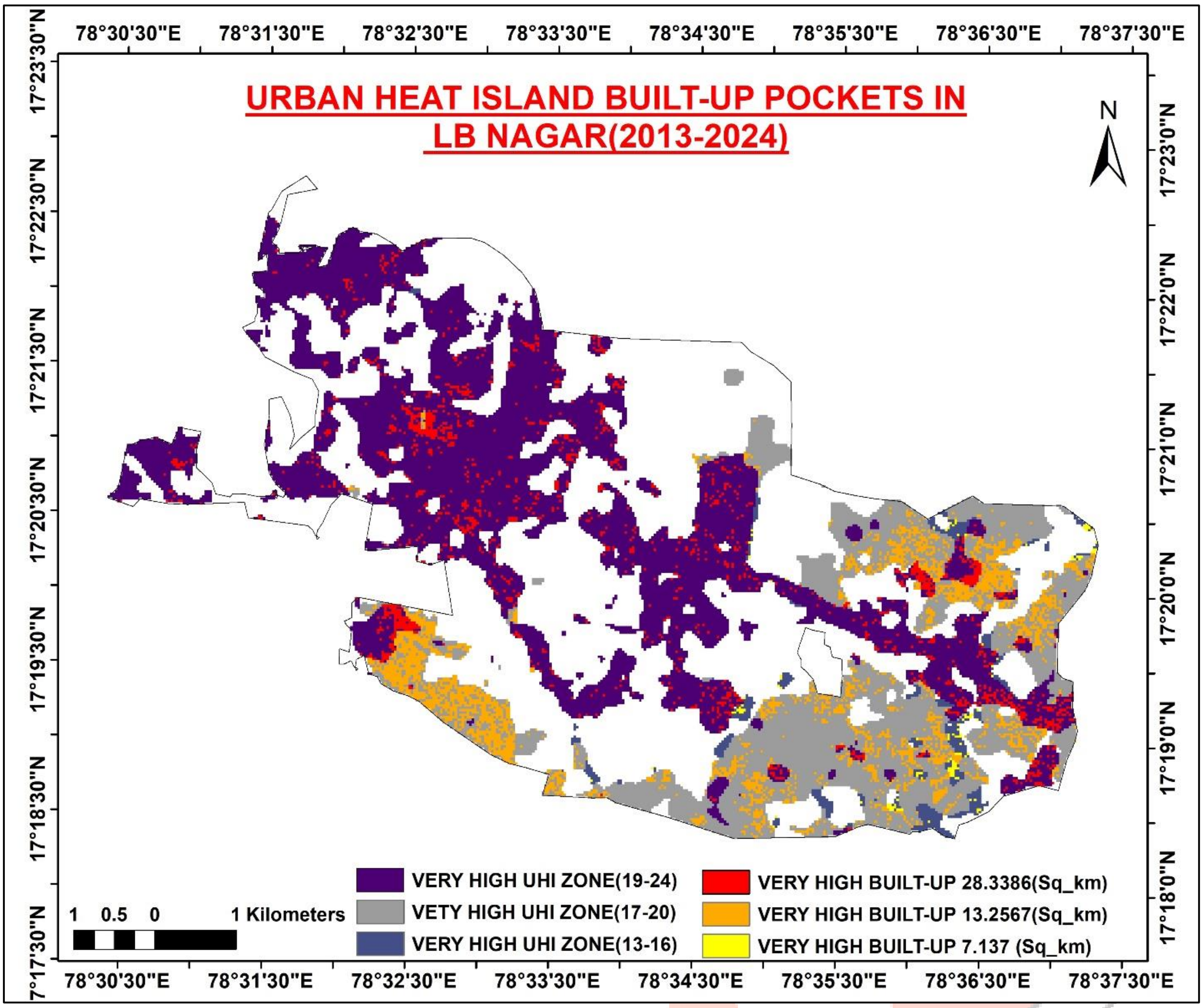

Figure 10 Distribution of Very High Urban Heat Island (UHI) Built-Up Intensity in LB Nagar (2013–2024)
(Source: Generated by the author using Landsat 8 OLI/TIRS satellite and spatial analysis in ArcGIS)

The fusion of fragmented heat intensity pockets into significant pockets reveals that high built-up cluster enhances the thermal storage capacity of the city and simultaneously reduces the evapotranspiration potential, thereby increasing urban heat island effects. The graphical representation of the Figure 10 also supports this fact.

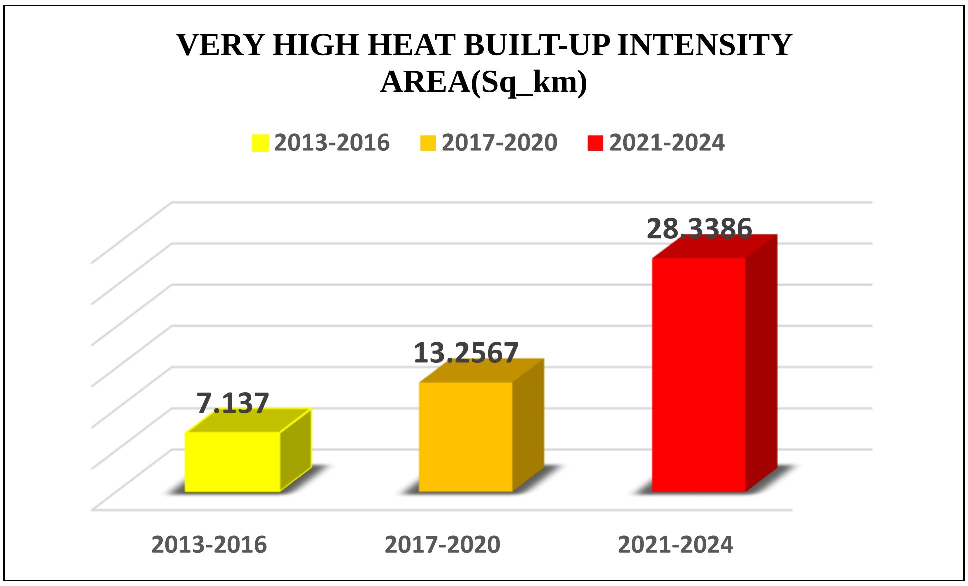

Figure 10 Very High Heat Built-Up Intensity Area in LB Nagar (2013–2024)
(Source: Prepared by the Author using data of Table 4 and MS -Excel)

4. CONCLUSION:

This research study is based upon remote sensing enabled temperature intensity and built-up agglomeration framework study in LB Nagra from 2013 to 2024. It establishes a significant and methodological relationship among land use and land cover changes, urban density, land surface temperature change and escalating urban heat island effect. The study proves that over the time period, rapid urbanization has not only altered the geographical configuration of the city but also has changed the heat dynamics of the city.

From 2013 to 2024, urban landscape has been increased in a continuous and clustered pattern. Water bodies, dense vegetation, mixed open land and fallow urban land have decreased as well as transformed into built-up areas. Such kind of non-viable land modification has limited the evapotranspiration and decreased the natural thermal cooling procedure of the city. As a result, the LST range has shifted upward and the urban heat island zones have expanded rapidly. The heat intensity around built-up has also increased in a progressive manner. It has transformed from isolated pockets to integrated continuous urban heat core.

The central, southern and western zones of the city have arisen as influential thermal axis as the UHI magnitude of the city has reached up to 5.2 °C during 2021–2024. On the other hand, the cooling pockets which were situated in the north-eastern and eastern margin, became restricted and fragmented. This spatial shift of thermal cores indicates quantitative heat escalation inside the city. This research works proves that consolidation of built-up areas is one of the key determinants of climate change in urban areas, as it creates thermal heterogeneity and persistent thermal heat urban cores.

5. POLICY AND RECOMMENDATION:

1. This research underscores that unchecked urban densification without ecological integration leads to intensified thermal vulnerability. The LB Nagar case illustrates how peri-urban
2. Embedding periodical heat monitoring by institutionalization.
3. Urban built-up should be under heat sensitive regulation.
4. Promoting the use of reflective roof cooling materials and permeable surface for construction.
5. Restoration of declines water bodies and dense vegetation areas.
6. Land use and city development planning should be under climate resilience guidelines.
7. Reducing the non-viable impervious structure enhancement and controlling excessive flooring space index.
8. Urban densification should run alongside with ecological integration so that thermal vulnerability can be controlled.

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