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GIS-Based Environmental Impact Assessment of Urban Infrastructure Growth on Land Surface Temperature and Urban Green Cover: A Case Study of Mysuru City, India

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Abstract:

The fast urbanization also changes the land cover, lowers the vegetation, and increases thermal stress in urban areas. This paper evaluates the spatial correlation among urban growth, loss of green cover, and surface temperature of land in Mysuru, Karnataka, in terms of multi-temporal Landsat 8 imagery and GIS analysis. Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-up Index (NDBI), and Land Surface Temperature (LST) had been calculated with the aim to assess vegetation distribution, the extent of built-up, and urban heat island (UHI) patterns. The percentile-based thresholds were used to determine high built-up-high LST zones and loss areas of green cover and a ward-level environmental vulnerability assessment was performed. The findings indicate that there is a high spatial relationship between high population density in built-up areas, low vegetation, and high surface temperatures especially in central and fast growing wards. The research creates a strong, spatial explicit model of defining environmentally susceptible areas and upholds climate-sensitive urban development in Mysuru.

Keywords: Urban Heat Island, NDVI, NDBI, Land Surface Temperature, Mysuru

Introduction:

The effects of urbanization on the environment are very immense and include land cover changes, loss of vegetation, and heightening of temperatures. The sudden increase in the built-up areas adds to the Urban Heat Island (UHI) effect, which increases the thermal stress and environmental vulnerability of cities. Remote sensing is a potent instrument to keep track of these modifications, which allows generating indices like NDVI of vegetation, NDBI of built-up areas and Land Surface Temperature (LST) of thermal patterns. By combining such datasets with the help of GIS-based spatial analysis it is possible to identify high-risk areas as well as environmentally vulnerable wards. The paper analyzes the spatial connection of urbanization, loss of green cover and thermal stress in Mysuru city. The urbanization trend is changing the world cities by changing not only the land use and land cover but also decreasing vegetation and increasing thermal stress, which adds to urban heat islands (UHI). GIS and remote sensing research studies have been of essential information on these dynamics in various urban settings. The Pochodyla et al. (2025) created a GIS-based framework of the Land Use Indicator Analysis to determine areas of environmentally stressed urban areas to plan blue-green infrastructure. Debnath et al. (2025) showed that LST and vegetation, water and built-up indices were highly correlated in Siliguri, which showed how land cover dynamics affected the surface temperature. Nathawat et al. (2025) and Duan et al. (2025) found that the reduction in the green cover and the fast growth of built-up areas have a significant effect on the LST and the appropriateness of urban green infrastructures in Jaipur and Okara District, Pakistan. Spatial heterogeneity of Sekondi- Takoradi, Ghana was highlighted by Biney et al. (2026), whereas vegetation expansion was capable of reducing daytime LST even in hyper arid regions such as Abu Dhabi, as demonstrated by Almazroui et al. (2025). Al-Faisal et al. (2021), Kanga et al. (2022), Patel et al. (2025), Zięba-Kulawik et al. (2025), and Sheriff et al. (2026) in Dhaka, Rajshahi, Bangalore, and Chennai have consistently exhibited that the high LST and amplified UHI impacts are directly linked to rapid urban development and reduction in vegetation along with dense built-up areas. In spite of these contributions, the majority of the studies are based on two-dimensional analyses, have a short study period, and rarely map UHI hotspots or environmentally sensitive wards. What is more, a spatially integrated framework showing the loss of green cover, high-built zones, and regions of thermal stress at fine scales has not been found often even though NDVI, NDBI, and LST correlations have been frequently reported. Thus, the paper is devoted to Mysuru, where the connections between urban growth, loss of green cover, and surface temperature are examined, and the UHI hotspots and wards at risk are identified, which can be utilized to propose the spatially explicit framework to enable climate-sensitive urban planning and sustainable green infrastructure planning.

Materials and Methods:

1. Study Area: The research is based on Mysuru, a fast urbanizing city in the southern part of India, in Karnataka with a latitude of about 12.3 N and a longitude of 76.6 E. Mysuru is known to have a history and cultural value, which has encountered significant growth of built-up areas over the past decades. The city has a tropical savanna climate, which has strong dry and wet seasons. It has a wide range of land cover; it contains urban settlements, agricultural land and green space which makes it the best study area in the evaluation of the effects of urbanization and urban heat islands on the environment.

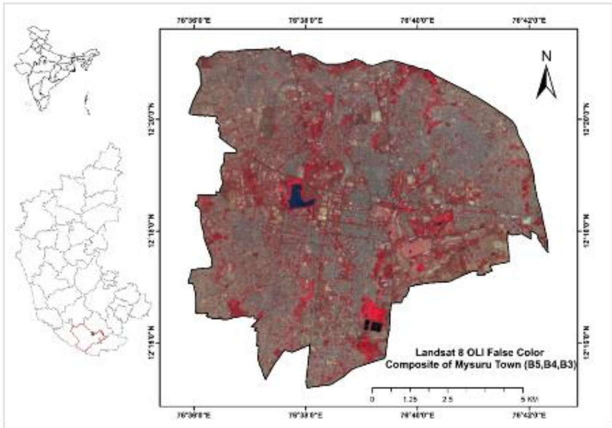

Figure 1 : Location map of the study area.

2.Data Sources and Processing: The analysis uses NDVI (Normalized Difference Vegetation Index) from Landsat 8 OLI (30 m) to assess vegetation cover and identify green cover loss. NDBI (Normalized Difference Built-up Index), also from Landsat 8 OLI (30 m), is employed to detect built-up and urban areas. Land Surface Temperature (LST) is derived from Landsat 8 TIRS (30 m) to map thermal stress and urban heat islands. High built-up and high LST zones are identified by combining NDBI and LST, while green cover loss zones are derived from NDVI. Town and ward boundaries obtained from the Karnataka GIS portal are used to locate and analyze environmentally vulnerable wards.

Table 1: Summary of Remote Sensing Data and Ward-Level Environmental Analysis

Data/Product	**Source**	**Spatial Resolution**	**Purpose / Use**
NDVI (Normalized Difference Vegetation Index)	Landsat 8 OLI	30 m	Assess vegetation cover and green cover loss
NDBI (Normalized Difference Built-up Index)	Landsat 8 OLI	30 m	Identify built-up and urban areas
LST (Land Surface Temperature)	Landsat 8 TIRS	30 m	Detect urban heat islands (thermal stress)
High Built-up + High LST Zones	Derived (NDBI & LST)	30 m	Identify urban heat stress areas
Green Cover Loss Zones	Derived (NDVI)	30 m	Identify vegetation degradation
Town and Ward Boundary	Karnataka GIS portal	-	To identify vulnerable wards

Methods:

1.Data Acquisition: Landsat satellite images were acquired from Google Earth Engine (GEE). Vegetation indices, built-up index and land surface temperature were generated using Landsat 8 OLI and TIRS data. The analysis was performed with the cloud-free images of the Mysuru urban area taken in dry season to minimize atmospheric influence. Satellite data at source level (as both TOA) in Level-2 terrain corrected were collected and projected to UTM Zone 43 N for spatial analysis. Data was cleaned and rerouted to ensure quality and compatibility.

From Landsat imagery, three main products were produced:

i). Normalized Difference Vegetation Index (NDVI): The NDVI was calculated from the red and near infrared bands (Rouse et al., 1973), between -1 to 1. The larger the value of NDVI, the denser vegetation it represents and is applied to detect greenery cover and reduction in city.

NDVI = $\frac{NIR-Red}{NIR+Red}$ ---- (Equation 1)

ii). Normalized Difference Built-up Index (NDBI): To measure built-up regions, NDBI was computed utilizing the near-infrared (NIR) and shortwave infrared (SWIR) bands (Zha et al., 2003).

NDBI = $\frac{SWIR-NIR}{SWIR+NIR}$ ---- (Equation 2)

Higher urbanization is indicated by positive NDBI values, whereas vegetated or unbuilt-up surfaces are indicated by lower or negative values. This index served as the foundation for evaluating built-up intensity and urban growth.

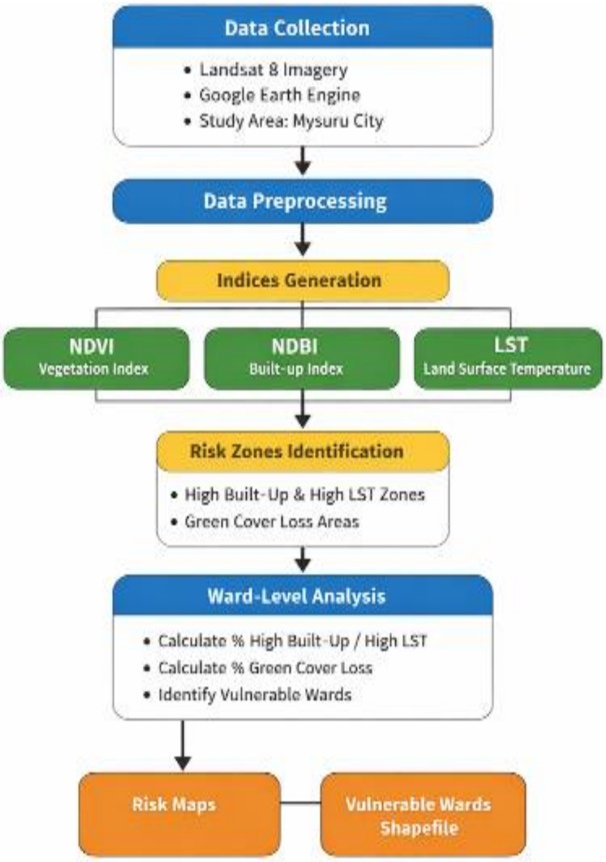

Figure 1 : Flowchart of methodology.

iii). Land Surface Temperature: LST was derived from Landsat 8 TIRS thermal bands by first converting digital numbers (DN) to spectral radiance:

$L_\lambda = M_L \cdot Q_{cal} + A_L$ ---- (Equation 3)

Then, brightness temperature (in Kelvin) was computed:

$T_B = \frac{K_2}{\ln\left(\frac{K_1}{L_\lambda}+1\right)}$ ---- (Equation 4)

Finally, the emissivity-corrected LST was calculated as:

$LST = \frac{T_B}{1+\left(\frac{\lambda \cdot T_B}{\rho}\right)\cdot \ln \varepsilon}$ ---- (Equation 5)

where $M_L$and $A_L$are radiometric rescaling factors, $Q_{cal}$is the digital number, $K_1$and $K_2$are band-specific thermal constants, $\lambda$is the wavelength of emitted radiance, $\rho = h \cdot c/\sigma$, and $\varepsilon$is the surface emissivity (Li et al., 2013).

iv). Urban Heat Island: NDBI and LST assessments were combined to evaluate the environmental effects of urbanization:

v). Hotspots for Urban Heat Islands (UHI): UHI hotspots were defined as regions having LST values higher than the 75th percentile. To evaluate the connection between high built-up intensity and greater surface temperatures, NDBI was superimposed over these zones.

NDVI, NDBI, and LST were integrated to perform an environmental vulnerability assessment at the ward leve.

- **High Built-up + High LST Zones:** Urban heat stress zones, or areas of high urbanization and thermal danger, were defined as pixels where both NDBI and LST exceeded the 75th percentile.
- **Green Cover Loss:** NDVI values of less than the 25 th percentile were identified as ecologically sensitive and were believed to reflect a loss or degradation of vegetation.
- **Environmentally Vulnerable Wards:** The risk areas highlighted above were overlaid with the shapefile of the wards in Mysuru. The proportion of all wards affected by high urbanization, high temperatures and reduction in green cover was calculated. Environmentally vulnerable wards in either category (that is, those who occupied over 20 percent of the total area) were used providing a more accurate spatial representation of urban.

Results and Discussions:

1.Normalized Difference Vegetation Index (NDVI) -Mysuru. Figure 3 a) NDVI analysis shows the divergent vegetation distribution with high values around parks, institutional campuses, and the peripheral green cover. The urban core has a predominance of low values of NDVI which was a result of vegetation loss as a result of urbanization. Scientifically, the following spatial pattern proves the cooling and stabilizing effect of vegetation and the need to preserve and expand green spaces to reduce the increase of urban temperatures in Mysuru.

2.Normalized Difference Built-up Index (NDBI) - NDBI is a useful measure of spatial intensity of urbanization with high values (Figure 3 b) indicating high density of residential, commercial and industrial areas. These regions coincide well with high temperatures of land surface, meaning that there must be a direct correlation between built-up growth and thermal stress. Scientifically, NDBI is useful as a proxy to explain the dynamics of urban growth, which allows evaluating the impact of infrastructural growth on the environmental conditions of Mysuru.

3.**Land Surface Temperature (LST) (2024-25)** : Figure 3 c shows a significant spatial variation in representation of the Land Surface Temperature in Mysuru in the 2024-25 period related to the land covers. Increased temperatures are always recorded in urban and industrial regions, and cooling effects are recorded in vegetated and water-filled regions. This thermal contrast scientifically justifies the role of surface materials and land-use change in urban energy balance, which is a quantitative basis of climate effects of urban growth of Mysuru.

4.Green Cover Loss Map: It is seen that Mysuru has a tendency to change its surfaces towards a built up area especially at the outer edges of the city and transport corridors which are evident in the green cover loss map (Figure 4 a). This becomes a decrease in vegetation that has undermined natural cooling process like evapotranspiration, which has led to local warming. Scientifically, the identified pattern is symbolic of heightened pressures of urbanization, which means that the level of ecological stress and the decreased environmental buffering capacity are becoming a reality in the urban environment of Mysuru.

5.High Built-up–High Land Surface Temperature Zones : The High Built-up-HighLST zones (Figure 4 b) in Mysuru show that there is high spatial association between dense built-up surfaces and high land surface temperatures. The central business districts and highly populated residential areas are the regions where heat trapping is high becaus **b** the use of impervious surfaces and a low number of vegetations. This is scientifically proven to prove the effect of the urban morphology in thermal amplification and to highlight the influence of the unplanned densification in microclimatic imbalance in Mysuru.

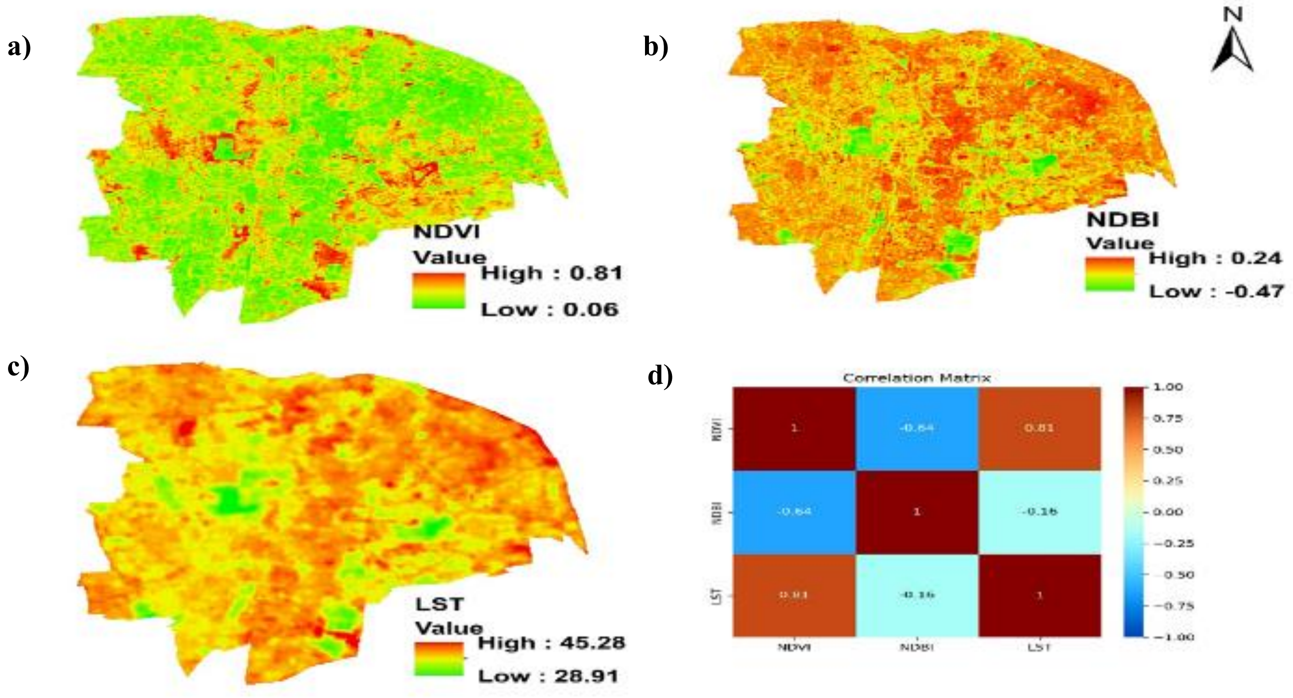

Figure 2 - NDVI , NDBI, LST and Correlation of these parameters.

6.Urban Heat Island (UHI) Hotspots: The Urban Heat Island hotspots of Mysuru (Figure 4 c) are clearly clustered in the densely populated and commercially active areas, in which anthropogenic heat emissions and surface impermeability predominantly occur. These hotspots are zones of constant thermal stress particularly during the peak seasons in summer. Scientifically, the distribution of them spatially can be interpreted as land-use intensity and decreased green covers, so they are very important focal areas in heat mitigation and urban climate resilience planning.

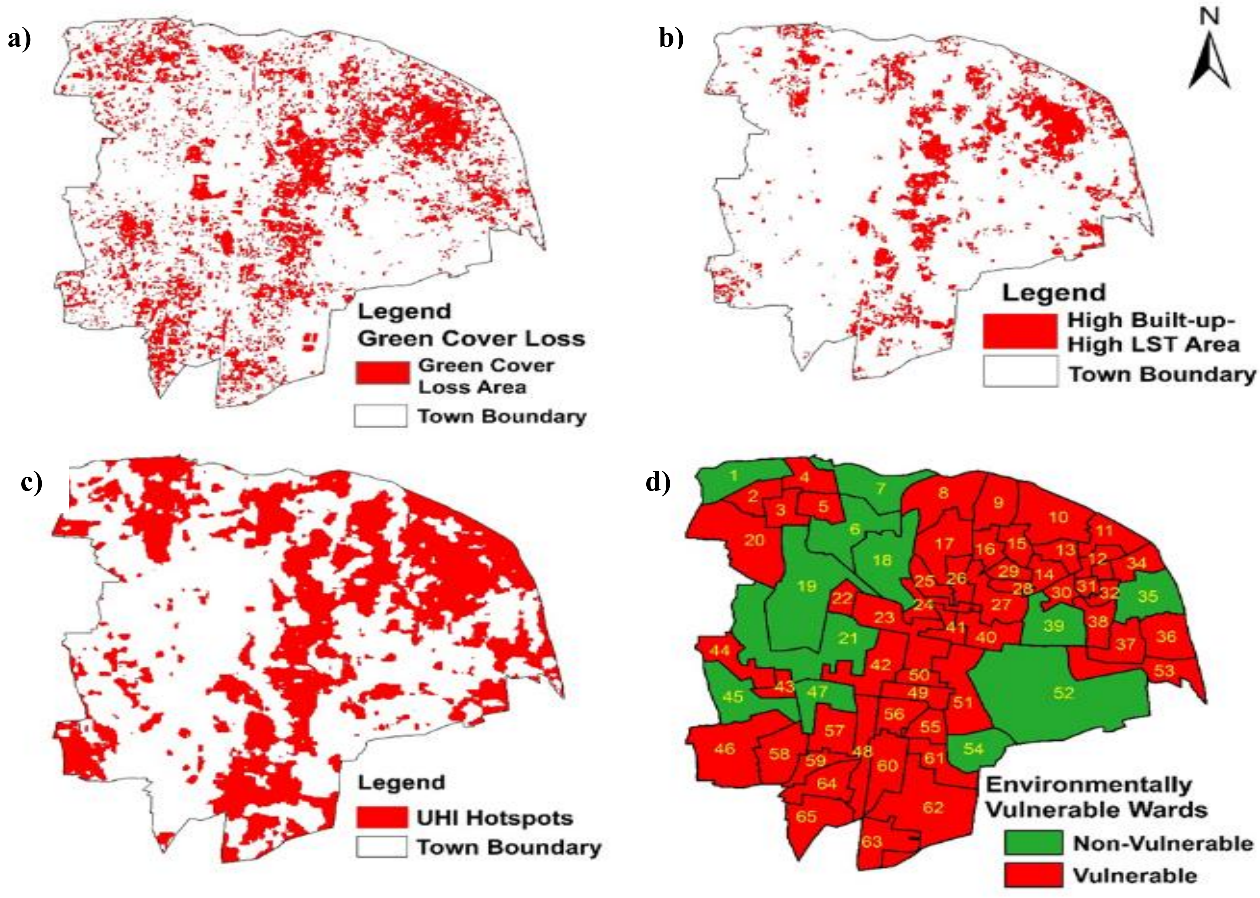

Figure 3- Showing the Green Cover loss High Built-up and LST, UHI Hotspots and Environmentally vulnerable wards.

7.Environmentally Vulnerable Wards

Environmentally vulnerable wards in Mysuru (Figure 4 d) are defined by the combination of high built-up density, reduced green cover, and high surface temperatures of land. These wards tend to overlap with older and more urban cores, and fast developing areas, where infrastructure expansion has far surpassed environmental planning. Interactions between various stressors enhance the vulnerability to heat stress, environmental degradation, and reduced livability, which shows the priority areas of climate-sensitive urban actions.

Summary and Conclusions:

This paper employed remote sensing and GIS to determine the effects of urbanization on the environment of Mysuru. The analysis of vegetation cover, built-up intensity and surface temperatures was conducted using Landsat 8 OLI and TIRS data that was used in deriving NDVI, NDBI and LST. The UHI hotspots, zones where there is loss of green cover and where there was high built-up and thermo-stress areas were classified using percentile. Analysis in the ward level revealed that there were various places experiencing a combination of pressure of both vegetation loss and high temperatures. The spatial relationships between NDVI, NDBI and LST indicate that unplanned urbanization increases thermal stress. In general, the article proves that satellite-derived indices combined with GIS are a powerful tool to locate vulnerable areas within the environment and address sustainable city planning, development of green infrastructure, and climate-resilience in the fast-growing cities.

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