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Assessing the Impact of Land Use Land Cover Patterns on Land Surface Temperature in Dhaka Metropolitan Area A Geospatial Approach

Sk. Tanjim Jaman Supto

Department of Environmental Research, Nano Research Centre, Sylhet, 3114, Bangladesh
* Correspondence: sksupto7@gmail.com

Abstract: Bangladesh's capital, Dhaka, has one of the highest urban densities in the world and is one of the most crowded and quickly urbanizing megacities. The city's land use and land cover (LULC) has changed significantly in recent decades due to economic growth, population pressure, and infrastructural construction. The urban thermal environment is significantly impacted by these changes. From 1990 to 2025, this study examines the spatiotemporal link between land surface temperature (LST) and LULC changes in the Dhaka Metropolitan Area. We measured LULC transitions and associated LST fluctuations using a geospatial method that combines Landsat data, LULC classification, and LST retrieval by thermal band analysis. Significant urban development into arid land 22 km2 and the conversion of vegetation 16 km2 and water bodies 25 km2 to urban areas are both revealed by the LULC change matrix. Urban regions have the highest mean temperature 21.05 °C, followed closely by arid terrain 21.26 °C, while vegetation has a slightly lower mean 20.59 °C, according to LST study. Water bodies, on the other hand, have a significantly lower mean temperature of 16.27 °C, underscoring their vital cooling role in the metropolitan thermal environment. Impervious materials and lower evapotranspiration have a significant impact on heat retention, as seen by the preservation of higher LST values in both built-up and bare surfaces. The results show that Dhaka's fast, uncontrolled development has resulted in the loss of water bodies as well as the extensive destruction of trees, green spaces, and vegetated regions. Impervious surfaces like concrete and asphalt have taken the role of these natural cooling systems, increasing heat retention and decreasing evapotranspiration. Because of this, LST in both populated and unpopulated areas are much higher, which exacerbates the Urban Heat Island (UHI) effect and fuels heat stress.

Keywords: Dhaka; Land Use Land Cover change; Land Surface Temperature; Urban Heat Island effect; Urbanization; LST; LULC; Urban Heat; UHI; Sustainable urban planning; Urban thermal environment; Spatio-temporal analysis

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1.Introduction

Rapid urbanization is transforming landscapes across the Global South, with profound consequences for urban climate. Dhaka, one of the world's most densely populated megacities, has experienced especially rapid and largely unplanned expansion driven by population growth, economic development, and infrastructure construction. Changes in LULC strongly influence the urban thermal environment by modifying surface properties such as albedo, heat storage, and evapotranspiration. Land Surface Temperature (LST) is therefore widely used to evaluate urban heat dynamics and the Urban Heat Island (UHI) effect[1]. In Dhaka, the replacement of vegetation and water bodies with impervious surfaces has intensified heat retention, while the loss of natural cooling systems has reduced the city's capacity to regulate surface temperatures.

Although numerous studies have investigated LULC change and LST patterns in Dhaka using remote sensing approaches, most focus on short time periods or analyze LULC and LST independently[2]. Many lack detailed transition-based analysis that links specific land cover conversions such as vegetation-to-urban or water-to-urban to corresponding LST changes. Consequently, the long-term spatiotemporal mechanisms through which different LULC transitions drive surface warming remain insufficiently understood[1–3]. This study addresses these limitations by examining the spatiotemporal relationship between LULC change and LST in the Dhaka Metropolitan Area over a 35-year period (1990–2025). By integrating multi-temporal Landsat data, LULC classification, transition matrix analysis, and thermal band–based LST retrieval, this research provides a more comprehensive and process-oriented assessment than most previous studies. The results clearly demonstrate how rapid urban expansion, particularly at the expense of vegetation and water bodies, intensifies surface heating and strengthens the UHI effect. The findings offer valuable insights for urban planners and policymakers by identifying critical land cover transitions that contribute most to thermal stress. The remainder of this paper outlines the methodology, presents the results of LULC and LST analysis, discusses their implications for urban climate resilience, and concludes with recommendations for sustainable urban development.Dhaka (Figure 1), the capital city of Bangladesh, is located on the lower Ganges Delta and forms the core of the Dhaka Metropolition, which covers approximately 1,530 km² with the central city around 360 km². The urban landscape is densely populated and has undergone rapid expansion over recent decades, making it a key focus of land use and environmental research. Geographically, Dhaka lies between approximately 23°36′–23°55′ N latitude and 90°08′–90°34′ E longitude, with a tropical, low-lying terrain prone to flooding. A network of rivers, including the Buriganga, Turag, Balu, and Shitalakshya, defines the city's hydrology, but the Buriganga River in particular forms a major southern boundary and has historically supported trade, transport, and settlement[4].

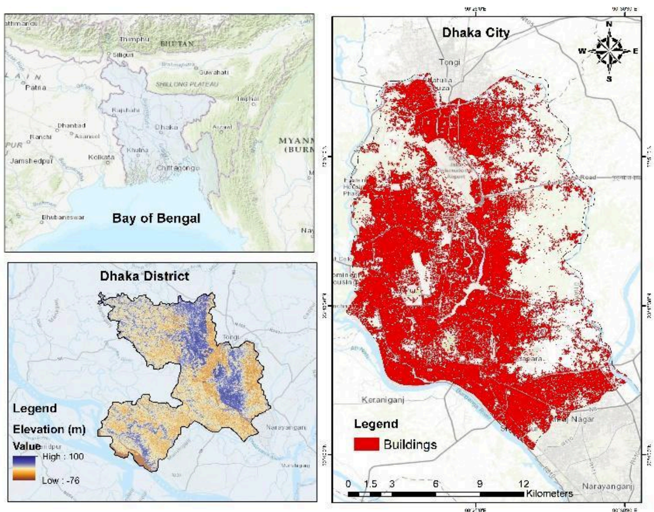


Figure 1. Dhala City Map.

2. Materials and Methods

This study used a geospatial approach to analyze the spatiotemporal relationship between LULC and LST in the Dhaka Metropolitan Area from 1990 to 2025 using multi-temporal Landsat imagery. Twenty-three cloud-free images for 1990 and forty-two for 2025 were processed through geometric, radiometric, and atmospheric corrections and co-registered to a common reference system. LULC maps were produced using supervised classification and post-classification comparison was applied to quantify land cover transitions. LST was derived from thermal infrared bands, and mean LST values for each LULC class were extracted using GIS overlay techniques. A fishnet grid with 10,000 sampling points was generated, and the extracted LST–LULC data were statistically analyzed using Python, with all spatial analyses conducted in ArcGIS Pro.

3. Results and Discussion

Rapid urban development in Dhaka over the past 35 years has been closely associated with a sustained rise in LST intensifying urban thermal stress. Published studies indicate that Dhaka's LST has increased by several degrees Celsius since the early 1990s, consistent with rapid expansion of built-up areas and loss of natural cooling surfaces.

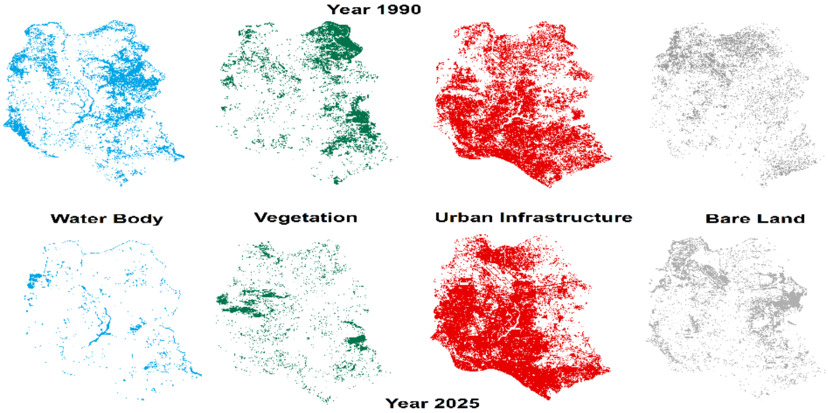
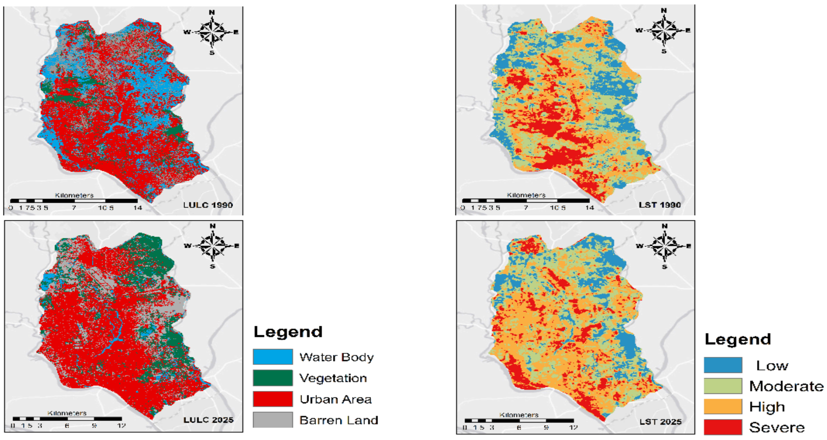


Figure 3. Change of LULC.

Areas such as Mirpur, Tejgaon, Uttara, Badda, Bashundhara, Old Dhaka, and parts of the eastern fringe are frequently identified as thermal hotspots where dense development and limited vegetation amplify surface heating. Concurrently, the pronounced loss of water bodies reflects strong pressure from land conversion linked to urban expansion, while increases in vegetation, barren land, and urban areas suggest a landscape increasingly shaped by anthropogenic influence.

LULC 1990	LULC 2025	Change (km^2)
Water Body	Water Body	8.3921
Water Body	Vegetation	16.972694
Water Body	Urban Area	25.09109
Water Body	Barren Land	19.640557
Vegetation	Water Body	0.553322
Vegetation	Vegetation	6.514067
Vegetation	Urban Area	15.819258
Vegetation	Barren Land	3.714062
Urban Area	Water Body	2.764338
Urban Area	Vegetation	21.596978
Urban Area	Urban Area	108.094798
Urban Area	Barren Land	21.433497
Barren Land	Water Body	2.033495
Barren Land	Vegetation	11.06318
Barren Land	Urban Area	21.540618
Barren Land	Barren Land	13.704763

Dhaka has experienced substantial LULC change over the study period, characterized by rapid expansion of urban areas alongside a decline in natural land covers. Figure 3 clearly illustrates that zones undergoing recent urban development correspond to areas with pronounced increases in land surface temperature. This spatial pattern indicates that newly built-up regions are emerging thermal hotspots due to the replacement of vegetation and water bodies with impervious surfaces. Overall, the figure highlights the strong linkage between recent urban growth and escalating surface warming in Dhaka.



(**a**) (**b**)

Figure 3. Spartio-temporal distribution.

Pearson correlation analysis shows that water bodies (r = −0.44) and vegetation (r = −0.51) are negatively correlated with LST, confirming their cooling influence. In contrast, urban areas (r = +0.45) and barren land (r = +0.18) exhibit positive correlations with LST.

4. Conclusion

This study demonstrates that rapid urban expansion in Dhaka from 1990 to 2025 has significantly altered LULC patterns, leading to a sustained increase in land surface temperature and intensified urban heat stress. The loss of water bodies and vegetation, coupled with the growth of impervious urban surfaces, has strengthened the urban heat island effect. The observed LST–LULC relationships confirm that land cover transitions play a critical role in shaping Dhaka's thermal environment. Urban planning policies in Dhaka should prioritize the protection and restoration of water bodies, expansion of urban green spaces, and climate-sensitive land-use planning to mitigate surface warming and enhance long-term urban climate resilience.

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Conflicts of Interest: The author declares no conflict of interest.

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