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Remote Sensing and Machine Learning Based Assessment of Energy Efficiency in Urban Built Environments of Dhaka City

Sk. Tanjim Jaman Supto and Md. Nurjaman Ridoy

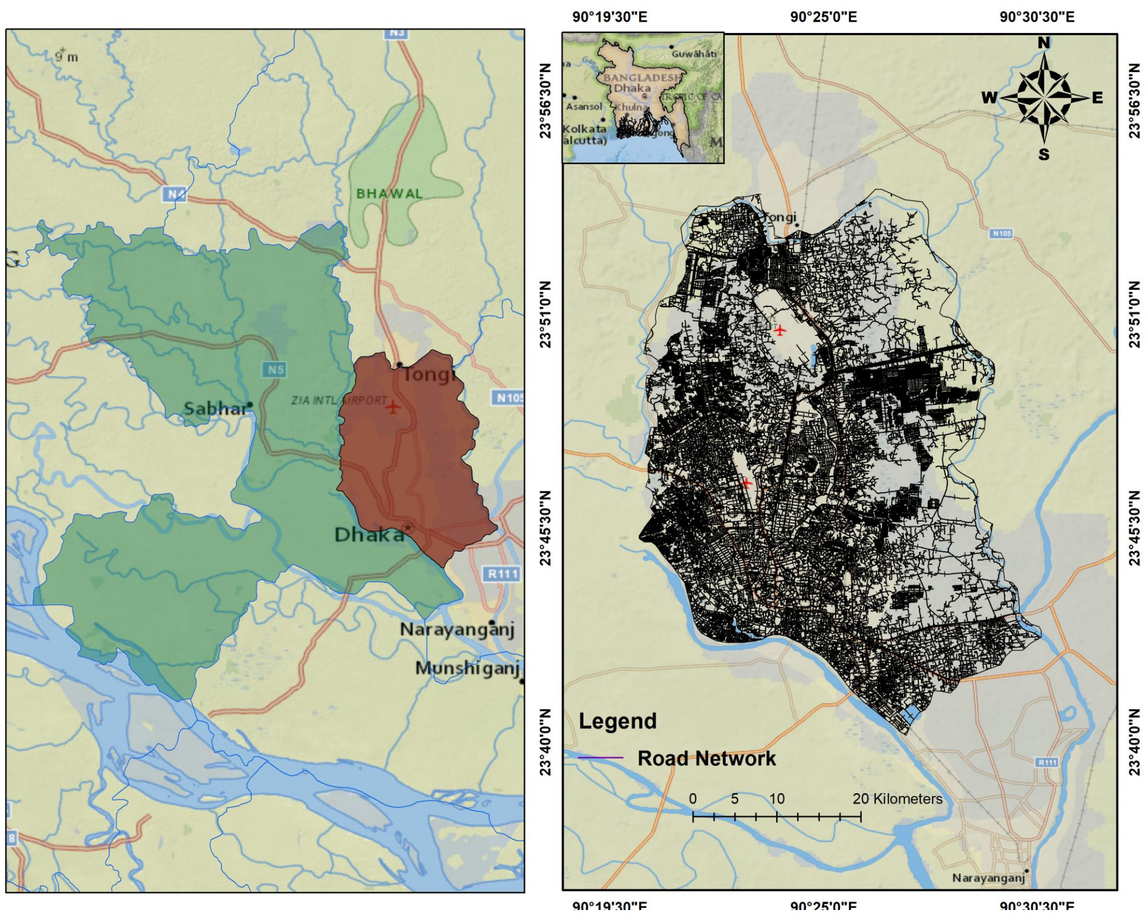
Department of Environmental Research, Nano Research Centre, Sylhet, 3114, Bangladesh

INTRODUCTION

The extreme urbanization process in Dhaka, Bangladesh, has created one of the most densely built metropolitan areas in South Asia and this has led to a significantly high rate of energy use and heat retention on the surface of the urban environment. This growth has worsened the thermal efficiency problem, largely caused by the spread of impermeable surfaces and the subsequent decrease of vegetation cover, in turn, increasing the land surface temperatures (LST) and reducing the total urban energy efficiency. The combination of remote sensing technologies with machine learning methodological can offer strong analytical instruments that can unlock these complex spatial patterns. The synthesis of satellite image, urban form data as well as environmental indices, including the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Built-up Index (NDBI) allow researchers to gain a subtle insight into urban thermal processes. The primary research conducted in the past highlights the vital role of energy-efficient urban design, green building construction, and sustainable architecture design in the reduction of heat stress and increase in energy efficiency within the built environment of Dhaka. The current research is based on data-driven methodologies that involve the use of remotely sensed variables and trained machine learning models to determine the trends of energy efficiency within the cityscape and inform climate-resilient urban planning of large cities. Urban greening, reflective roofing, and compact vertical development are some of the evidence-based interventions that can be mentioned as the results of this work. These actions can enhance thermal comfort and decrease energy consumption in rapidly growing cities.

Study Area

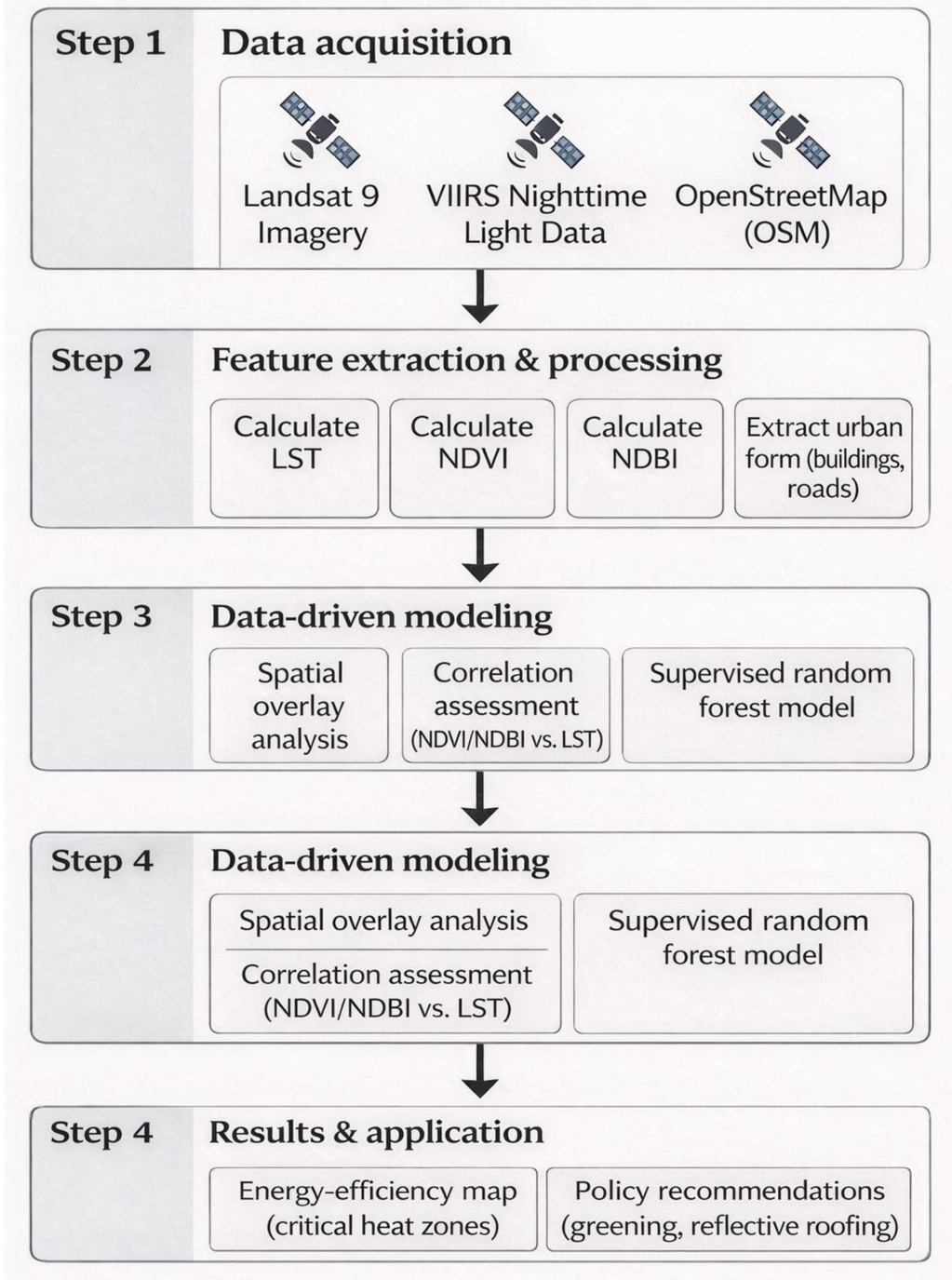
The current study focuses its efforts on Dhaka, Bangladesh, which is an emergent megacity that covers an area of 306 km_2 and has a population of more than 21 million inhabitants. Dhaka city is an eclectic mix of residential, commercial, and industrial buildings, and a tropical monsoon climate, both of which have an intensive impact on the urban energy consumption trends. Its dense and diverse built environment combined to make the city especially open to remote sensing and machine-learning-based analyses of energy efficiency. The study area was therefore defined through the use of a combination of satellite images and administrative boundary data, which further enabled the analysis of urban infrastructure in a comprehensive spatial manner as well as its energy nature.



Methodology

Data Sources:

- ❑ Landsat 9 Satellite Imagery
- ❑ VIIRS Nighttime Light Data
- ❑ OpenStreetMap (OSM)



Result

Results show that densely built areas, as well as high-illuminated precincts in Dhaka, exhibit significantly high land surface temperatures (LST), hence indicating poor energy efficiency. On the other hand, vegetated areas with peri-urban zones have relatively lower surface temperatures. The strength of constructed infrastructure turns out to be the major cause of LST variability, and biotic cover always suppresses thermal stress across the urban grid.

CONCLUSION

The study shows that rapid urbanization and unplanned development in Dhaka have significantly increased surface temperatures and reduced energy efficiency due to the expansion of impervious surfaces and loss of vegetation. By integrating remote sensing data, GIS, and machine learning techniques, the research effectively maps spatial patterns of thermal stress and identifies critical urban heat zones. The findings highlight that areas with dense built-up structures and low vegetation cover experience higher land surface temperatures, while green and peri-urban zones maintain cooler conditions, underscoring the cooling benefits of urban greenery. Strategies such as urban greening, green roofs, reflective roofing, and sustainable vertical development emerge as effective interventions to mitigate heat stress and improve energy performance in Dhaka's built environment. These nature-based solutions not only reduce indoor and outdoor temperatures but also contribute to carbon sequestration and enhanced human thermal comfort. Overall, this study provides valuable evidence to guide policymakers in implementing climate-resilient urban planning that promotes energy efficiency and thermal comfort in rapidly growing tropical cities

REFERENCES

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