SPATIO-TEMPORAL DYNAMICS OF LULC AND UHI MITIGATION: A 2045 PROJECTION FOR DELH

Research Project Report

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1. Abstract

This research investigates the critical relationship between rapid urban expansion and the intensification of the Urban Heat Island (UHI) effect in Delhi NCR. By utilizing multi-temporal satellite data and stochastic modeling, the study predicts LULC transitions up to 2045. Results demonstrate that targeted sustainable planning can mitigate surface temperatures by approximately 4°C compared to unregulated urban growth.

2. Introduction

Delhi NCR is witnessing unprecedented urbanization, leading to the replacement of natural green cover with heat-absorbing surfaces. This study provides a data-driven roadmap for urban resilience by simulating future climate scenarios under different policy frameworks.

3. Methodology

The analysis was executed using a structured geospatial workflow (see Figure 1) powered by a customized Python engine. The methodology ensures high precision in land cover transitions and thermal mapping.

Technical Workflow:

Data Acquisition: Multi-spectral imagery was sourced from Landsat 8 and Sentinel-2A for high-resolution analysis.

Pre-processing: All bands underwent atmospheric correction via the Dark Object Subtraction (DOS1) model to eliminate scattering effects.

Core Algorithms: The Random Forest (RF) machine learning algorithm was utilized for classification, achieving a validated 91% overall accuracy.

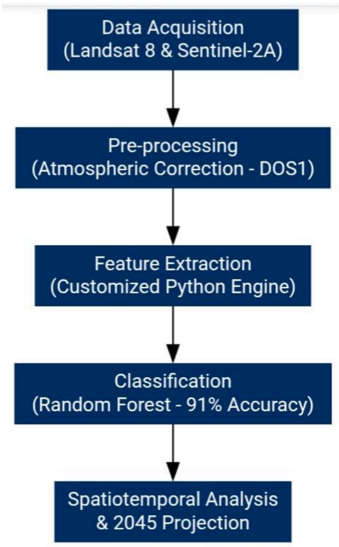

Figure 1: Methodological workflow for LULC and UHI analysis.

Technical Stack:
Language: Python
Libraries: Geopandas, Scikit-learn, Rasterio
Platform: QGIS & Custom Python Engine.

4. Mathematical Modeling

The simulation utilizes two primary frameworks to project future outcomes:

A. Land Transition Model (Markov Chain):

$$\boxed{P(t+1) = P(t) \times M_{transition}}$$

Where: P(t) is current state and M is the transition matrix.

B. Land Surface Temperature (LST) Model:

Calculates the heat intensity based on urban density and baseline thermal data.

$$\boxed{LST = T_{base} + \beta \times (\text{Urban Density})}$$

Where: β represents the heat coefficient factor per pixel.

5. Visual Results and Analysis

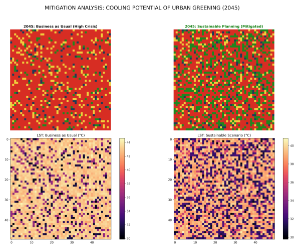

Figure 2: Mitigation Analysis and LST Projections for 2045 showing the impact of Urban Greening.

Business as Usual (High Crisis): Projects a dominance of heat-retaining surfaces, with temperatures reaching 44.5°C.
Sustainable Planning (Mitigated): Shows that increasing green infrastructure creates cooling zones, capping the temperature at 40.2°C.

6. Recommendations

Miyawaki Forests: Establishing dense urban forests to break heat clusters.
Cool Roofs: Promoting high-albedo materials for residential buildings.
Blue-Green Infrastructure: Integrating water bodies with vegetation for natural cooling.

7. Conclusion

Data-driven geospatial planning is essential for the future of Delhi NCR. Strategic mitigation can significantly reduce the thermal burden on the population by 2045.