Urban Heat and Green Spaces: A Novel Land Surface Temperature (LST) -Based Framework

Bridging LST monitoring and urban greening for enhanced thermal hotspot management

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1. Introduction

- Land Surface Temperature (LST) is a vital parameter for assessing urban heat and identifying priority areas for urban greening.
- LST is strongly influenced by urban features—built-up areas, vegetation, and water bodies.
- Recent advancements in remote sensing allow LST analysis at multiple spatial and temporal scales, helping map urban thermal hotspots.
- However, LST is sensitive to:
  - Seasonal variability
  - Temporary land-use changes
  - Weather anomalies
- These factors can complicate hotspot detection if not properly considered.
- Rapid developments in thermal sensors, algorithms, and data access have improved LST applications—but introduced uncertainties and artefacts.
- Previous related studies mostly focused on the Urban Heat Island (UHI) from a climate perspective or assess urban greening via ecological indices—with little integration of thermal factors.

Research Hypothesis

An integrated, LST-based framework that accounts for temporal, spatial, and sensor-specific variations can significantly enhance the accuracy of thermal hotspot identification and support data-driven urban green space management.

2. Study area, data and methods

Data for analysis

Data for validation & interpretation

- Landsat-derived LST data (Sensors 5, 7, 8, 9).

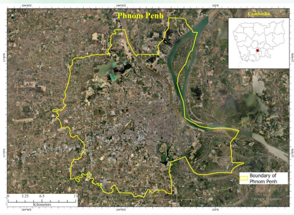

Figure 1: Study area

- The tropical city of Phnom Penh, Cambodia (Figure 1).

Methods for LST retrieval

- Initial LST estimation using the Radiative Transfer Equation (RTE).
- For time-series analysis, the Single-Channel algorithm was applied.
- Currently, Landsat Analysis-Ready LST products are used for further analysis.

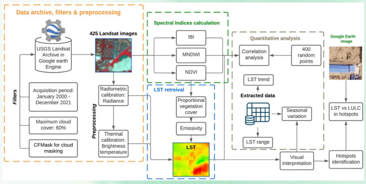

Figure 2: Overview of methodological overview (partial)

3. Results (till now), learnings and challenges

1

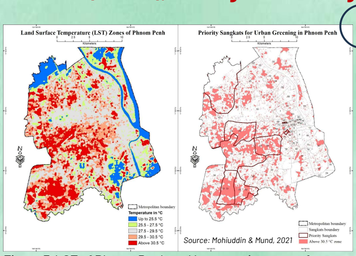

Figure 3: LST of Phnom Penh and hotspots in terms of administrative units (Sangkats)

- LST provides an overview of the urban surface temperature distribution and helps identify hotspots (Figure 3).
- However, LST from a single timestamp lacks consideration of:
  - *Temporal LST changes*
  - *Seasonal variability*
  - *Weather anomalies*
- Therefore, further analysis of LST changes and their correlation with urban vegetation is necessary.

2

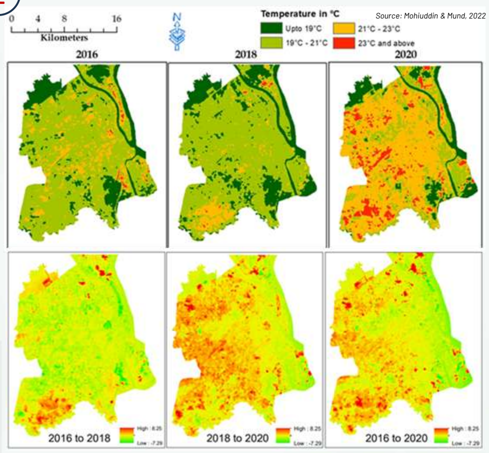

Figure 4: LST distribution and changes in Phnom Penh during 2016, 2018 & 2020

- Temporal LST changes are visible across multiple timelines (Figure 4).
- The cooling effect of Urban Green Infrastructure (UGI) is evident compared to other land uses (Figure 5).
- A strong correlation exists between LST and urban vegetation (Figure 6).
- Seasonal variability and anomalies are not yet fully addressed.
- Further time-series analysis is required to better understand thermal dynamics.

4

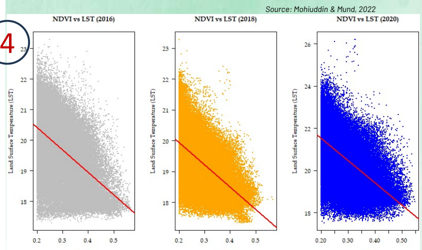

Figure 6: Statistical correlation between LST & NDVI in Phnom Penh

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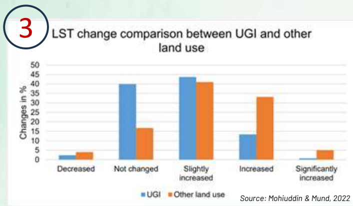

Figure 5: Cooling effect of UGI in terms of LST

5

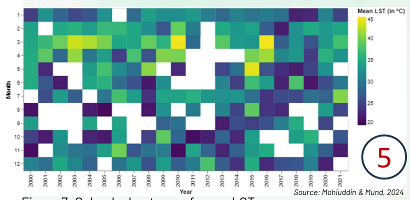

Figure 7: Calendar heatmap of mean LST (white boxes inside the figure represent no data)

6

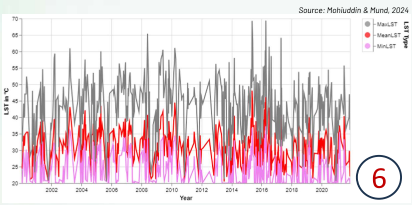

Figure 8: Trend of minimum, mean and maximum LST (2000–2021)

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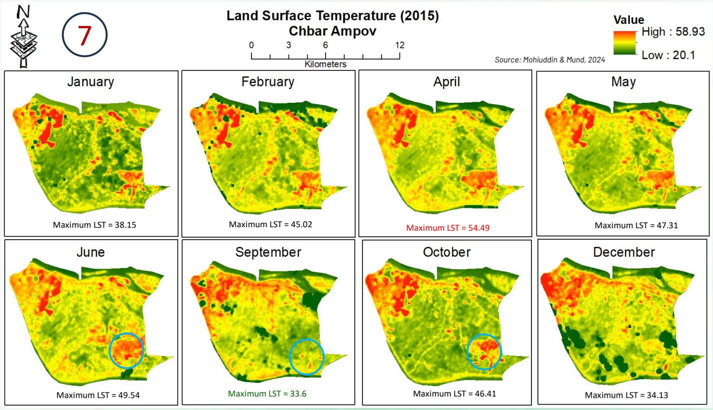

Figure 9: LST (in °C) in different months from 2015 demonstrating seasonal variability

- Extended time series provide a comprehensive view of thermal dynamics (Figures 7, 8).
- Strong seasonal variability in LST is observed (Figure 9).
- Cloud-induced anomalies must be considered during analysis (Figure 9).
- Visual links between LST and land use/land cover (LULC) changes are apparent (Figure 10).

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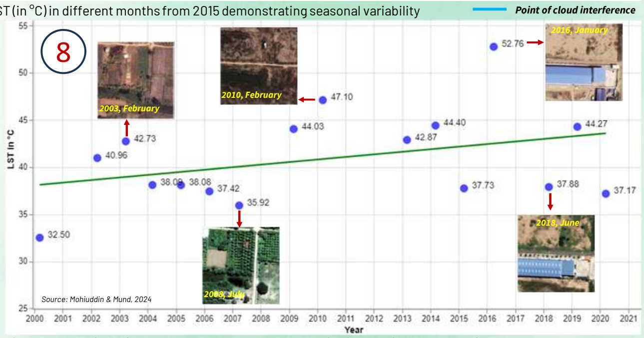

Figure 10: Relationship between LST and LULC changes in single point of observation

4. Future Work and Methodological Development

4.1 Systematic Approach to Remove Artefacts

- *Although Analysis-Ready LST data simplify processing, lower-range artefacts are prevalent.*
- *A systematic artefact removal approach will be developed.*

4.2 Advanced Thermal Hotspot Analysis

- *A thermal hotspot analysis incorporating seasonal variability and anomalies will be conducted at different temporal resolutions.*
- *This approach aims to enhance the accuracy of hotspot identification.*

4.3 Development of an Urban Green Assessment Framework

- *Identified hotspots will be integrated with vegetation, water, and built-up data to create a comprehensive urban green assessment framework.*
- *This framework will assist city planners and administrations in decision-making related to urban greening and thermal comfort.*

List of publications till April 2025

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