# CLIMATE-SENSITIVE URBAN PUBLIC SPACE: A SUSTAINABLE APPROACH TO URBAN HEAT ISLAND MITIGATION IN COLOMBO, SRI LANKA

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(03/9908)



Degree of Doctor of Philosophy

Department of Architecture

University of Moratuwa
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Thesis submitted in partial fulfilment of the requirements for the degree Doctor of Philosophy

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# Declaration

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other university or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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N G R Perera



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…… ……

Signature of Supervisor: Date:

Prof. P K S Mahanama

*dedicated to;*

*my children; ananya, vinaya, dhruv*

*my wife; pendrine*

*and to my parents*

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# Abstract

Manipulating the urban fabric is fundamental to mitigate and adapt to the warming trend in the growing high-density tropical cities. However, excessive data needs, weak analytical methods and the un-coordinated planning regimes pose barriers to achieving this aim.

The main aim of the research is to bridge the gap in urban design-climate links, being translated into guidelines for real-world applicability in a background climate affected by global warming. The study is limited to the warm humid tropical climate of Colombo, Sri Lanka, as the experimental context for the research.

The main research questions are related to; the microclimatic background condition under current and future warming scenario; sensitivity of the key urban morphology variables that will define and drive the decision making process; and the planning and policy implications that link climate and urban design. The study employs the Local Climate Zone (LCZ) system as a method of contextual analysis, together with LCZ-based morphology simulations (ENVI-met), utilising Mean Radiant Temperature (MRT) as the key dependent variable. Statistical analyses (SPSS) of the results test the applicability and sensitivity of urban morphological variables to help mitigate / adapt to local and global warming.

The findings indicate that the Sky View Factor is the most influential urban indicator of local climate. In general, night-time shows better correlation with MRT. The nature of the Pervious Surface Cover has little or no effect on reducing MRT. And, the correlation of variables with MRT is stronger in a climatic background affected by global warming.

The work contributes a 'conceptual framework' for the deeper understanding of the effect of building morphology on local level warming in the tropics. Policies that give effect to these findings are presented in a manner that requires minimal data input. Protocols for mapping of LCZs and relative warming effects, and sensitivity analysis of key design parameters for the mitigation of UHI in the tropics are presented. The socio-economic and planning practice implications of a LCZ-based planning approach are explored.



*Keywords: ENVI-met, Global warming, Local Climate Zones, MRT, Urban Heat Island, Warm Humid Tropics*

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# List of Abbreviations

| | |
|---|---|
| AVA | Air Ventilation Assessment |
| BSF | Building Surface Fraction |
| CASBEE | Comprehensive Assessment System For Built Environment Efficiency |
| CMC | Colombo Municipal Council |
| CMRSP | Colombo Metropolitan Region Structure Plan |
| DGP | Development Guide Plans |
| FAR | Floor Area Ratio |
| GIS | Geographic Information System |
| GSF | Green Surface Fraction |
| HRE | Height of Roughness Elements |
| IPCC | Intergovernmental Panel on Climate Change |
| ISF | Impervious Surface Fraction |
| LCZ | Local Climatic Zones |
| LQ | Location Quotient |
| MRT | Mean Radiant Temperature |
| PET | Physiological Equivalent Temperature |
| PMV | Predicted Mean Vote |
| PSF | Pervious Surface Fraction |
| q | Specific Humidity |
| q.rel | Relative Humidity |
| RMSE | Root Mean Square Error |
| SHIM | Surface Heat Island Model |
| SPSS | Statistical Package for the Social Sciences |
| SVF | Sky View Factor |
| t | Temperature |
| UBL | Urban Boundary Layer |
| UCL | Urban Canopy Layer |
| UCMap | Urban Climate Map |
| UDA | Urban Development Authority |
| UHI | Urban Heat Island |
| u, v, w | Wind Velocity |
| wDir | Wind Direction |
| WMO | World Meteorological Organisation |
| wSpeed | Wind Speed |
| WUDAPT | World Urban Database And Access Portal Tools |

# List of Appendices