A "Local Climate Zone" based approach to urban planning in Colombo, Sri Lanka

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‘Problem Analysis’

- An in-depth understanding of the interaction between the physical form and the climatic context is crucial for the generation of climate sensitive urban planning approaches.

- However, data needs and methods of analysis remain problematic at present to achieve this.

‘The Aim’

- In this paper, we showcase a simpler method of contextual analysis using the Local Climate Zone (LCZ) system in warm humid Colombo, Sri Lanka.

- The work contributes towards a deeper understanding of the effect of building morphology on local level warming, with minimal data input.

- The aim is to help develop climate-sensitive planning and policy in warm humid climates.

‘Outline of the research’

In this context, we explore three main areas in the pursuit of bridging the gap in urban design-climate links –

1. LCZ deployment in data- scarce tropics;

2. Sensitivity analysis of design parameters for the mitigation of UHI and outdoor thermal comfort in a tropical context;

3. A "Local Climate Zone" based approach to urban planning in Colombo, Sri Lanka.

1. ‘LCZ deployment in data-scarce tropics’

The LCZ application in a warm humid climate setting (Colombo, Sri Lanka), draws upon studies by Perera, Emmanuel & Mahanama, (2012 and 2013).

- LCZ map of Colombo (and local warming)
- Effect of LCZ changes due to future plans for the city

The LCZ mapping used the ‘guide for classification’ developed by Stewart (2011)

- used the ‘urban block’ as the definition of the source area
- The process of ‘sub-classification’ of the primary LCZs is seen as an important step in relation to cities like Colombo

'LCZ Map of Colombo'

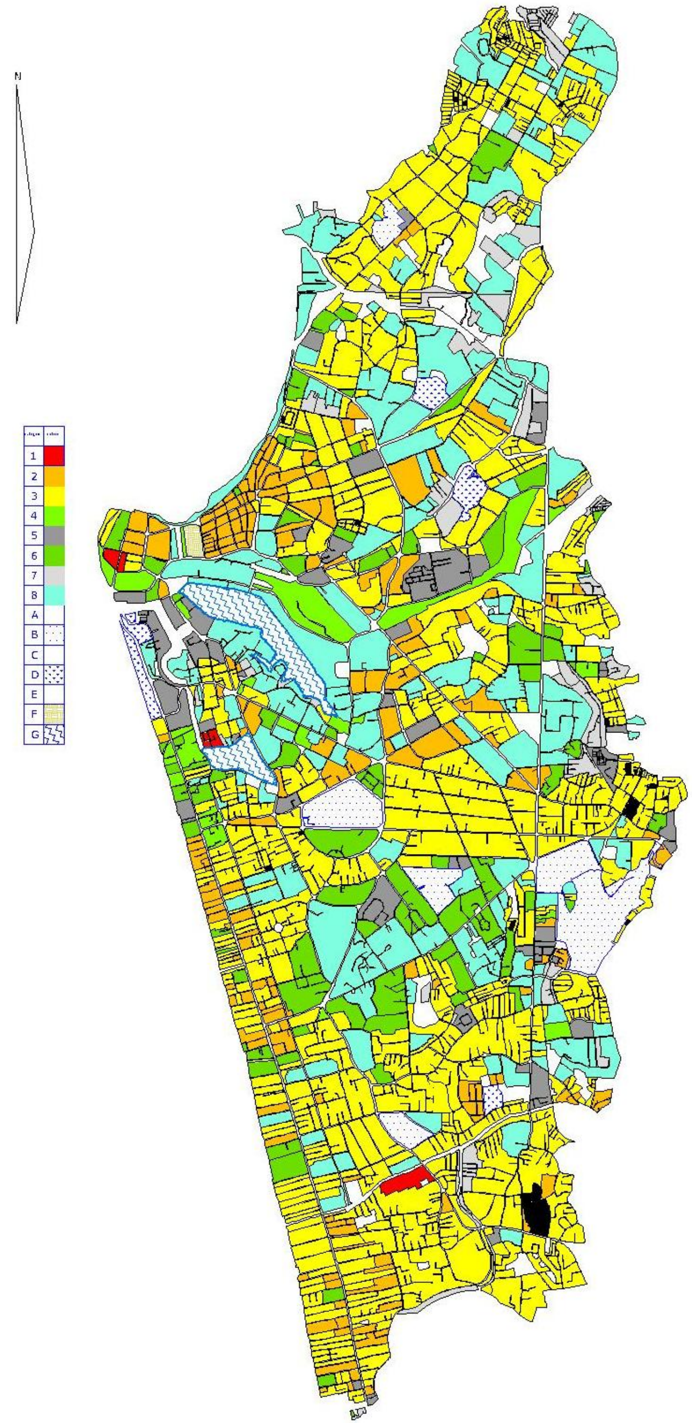
Dominated by low-rise residential and mixed-use zones

Most of the city is classified as LCZ3 (48.1%), LCZ2 (8.9%) and LCZ8 (23.7%).

LCZ1 (0.3%) and LCZ4 (1%) form a very small fraction of Colombo's built fabric.

A significant percentage falls under the category of LCZ7 (4.9%)

(Perera, et al. 2012)



LCZ data key denotes -1- Compact Highrise, 2 – Compact Midrise, 3 – Compact Low-rise, 4-Open High-rise, 5-Open Midrise, 6-Open Low-rise, 7-Lightweight Low-rise, 8-Large Low-rise, A-dense trees, B-Scattered Trees, C-Bush, Scrub, D-Low Plants, E-Bare Rock or Paved, F-Bare Soil or Sand, G-Water

‘Sub-classified LCZ Map of Colombo’

Likely local warming due to urban fabric changes in Colombo. Source - (Perera et al. 2012)

LOCAL CLIMATE ZONE	LOCAL CLIMATE ZONE (LCZ)– Sub Category														
	1	2	3	4	5	6	7	8	A	B	C	D	E	F	G
1	4.40														
2		3.96	3.56	4.15			3.22								
3		3.33	3.19	3.30	3.13	2.26	3.50								
4		4.16	4.02	4.35								4.12			
5			3.47	4.14	3.71					3.43		3.31	3.79	3.07	
6			1.63		2.29	1.87	0.89		1.21	1.03		0.80		0.09	
7			1.04				0.31								
8		1.48	1.29	1.37	1.19		1.56	1.10		0.57		0.52	1.15	0.20	
A									-0.12						
B										-0.09					
C															
D												-0.64			
E													1.04		
F														-0.90	
G															0.62

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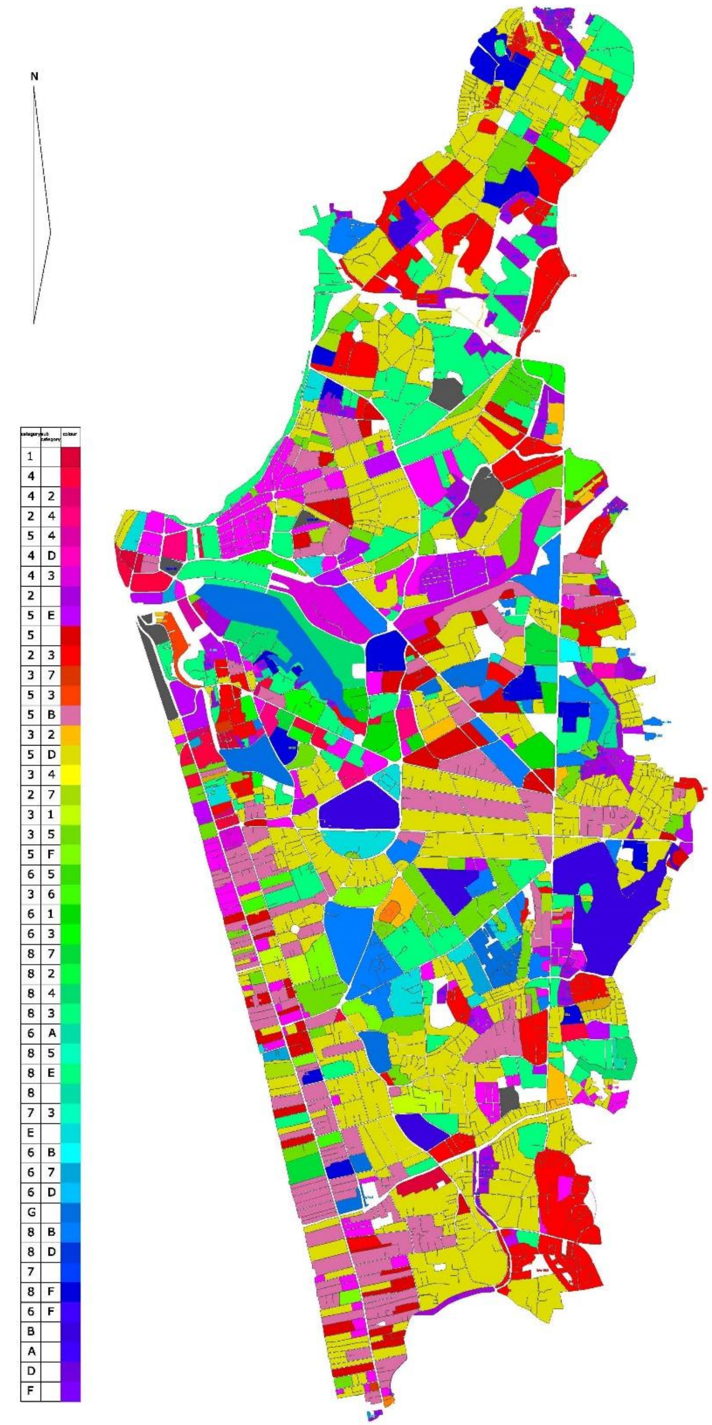


2. ‘Sensitivity analysis of design parameters for the mitigation of UHI and outdoor thermal comfort in a tropical context’

Parameters

The LCZ system defines value ranges of geometric, surface cover, thermal, radiative, and metabolic properties.

Sky view factor (SVF); Aspect ratio; Building surface fraction (BSF); Impervious surface fraction (ISF); Pervious surface fraction (PSF); Height of roughness elements (HRE); Surface admittance; Surface albedo; and Anthropogenic heat output. [see(Stewart & Oke 2012)]

We focus on the morphology aspects of the urban fabric – the geometric and the surface cover – to test the sensitivity and adaptability of these variables in a tropical context.

Parameters that can be easily regulated in an approach to generating planning and policy for climate sensitive urban spaces.

Background climate

Analysis looks at two climatic scenarios;

- the existing
- globally warmed background climate (projected for 2100, Colombo)

Under an A2 climate change scenario, Sri Lanka's Mean Temperature would rise as much as 2.4°C by the year 2100. (Samarasinghe, 2009)

Existing Buildings (all sites) - Source - (Perera, 2015)

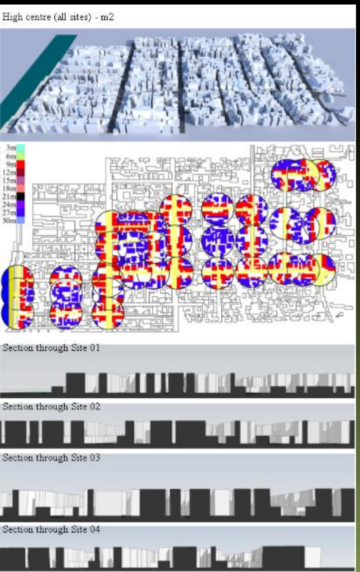
Site selection

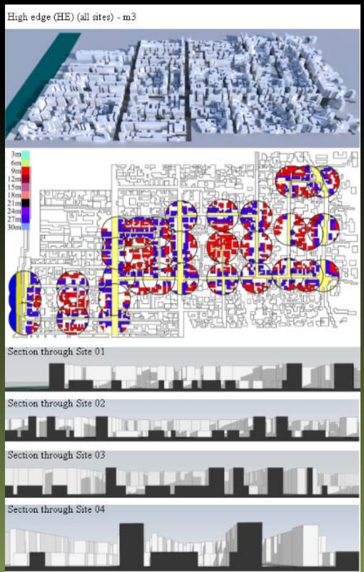
- Representative cross section of Colombo
- 4 sites – based on proximity
- 9 measurement (simulation) points
- 100m radius for morphology and surface cover analysis

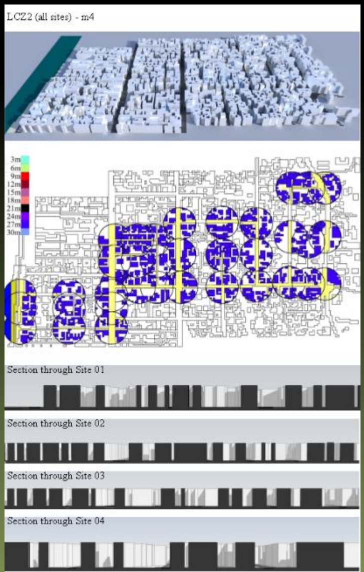
Simulation Matrix

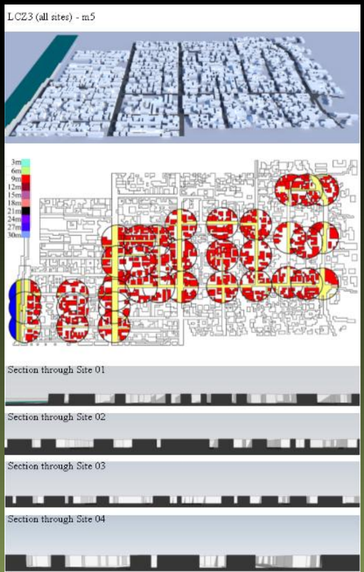
ENVI-met Simulation Matrix. Source - (Perera, 2015)

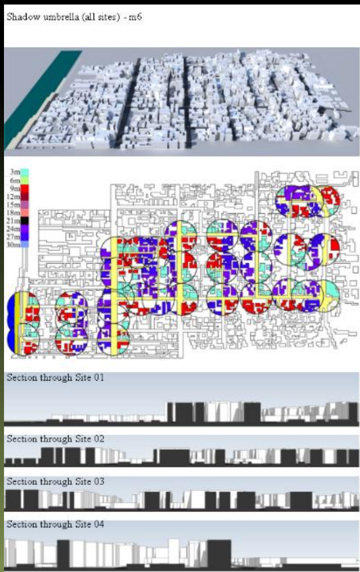
Cases		Site		Model		Receptor points		Streets	
Case 1	Models existing background microclimate conditions. Pervious surfaces are open soil	Site 1	Site between marine drive / Galle road	Base case	urban blocks and buildings are as existing	centre	Receptor point - a term generic to ENVI-met, denotes a measurement site in the simulation model. The simulation software generates specific data for each receptor point included. The rest of the output remains a part of the whole. The receptor points for each simulation model are in the cardinal directions as well as at the centre of the urban block. `	centre	Receptor points are amalgamated to create street profiles that bound a particular urban block. The street nomenclature depicts the boundaries of the block, together with the centre of the block.
Case 2	Models existing background microclimate conditions. Pervious surfaces are 50mm average density grass	Site 2	Site between Galle road / R A de Mel Mw (Galle road edge)	High centre	Blocks simplified as 9m street edges with 27m centre of the blocks. The models assume 15m of the block edge to be 9m.	East		North-South East facing	
Case 3	Models 'warmed' background microclimate conditions. Pervious surfaces are open soil	Site 3	Site between Galle road / R A de Mel Mw (R A de Mel Mw edge)	High edge	Blocks simplified as 27m street edges with 9m centre of the blocks. The models assume 15m of the block edge to be 27m.	North		North-South West facing	
Case 4	Models 'warmed' background microclimate conditions. Pervious surfaces are 50mm average density grass	Site 4	Site between R A de Mel Mw / Havelock road (Havelock road edge)	Lcz2	Simplified Blocks assume maximum and uniform building height of 27m.	West		East-West North facing	
				Lcz3	Simplified Blocks assume minimum and uniform building height of 9m.	South		East-West South facing	
				Shadow umbrella	Blocks assume a simplified shadow umbrella form. The blocks assume 4 distinct zones as follows; Southwest - 3m Northwest - 9m Northeast - 27m Southeast - 24m	Northeast Northwest Southeast Southwest			











Analysis of results - compare Mean Radiant Temperature (MRT) to the geometric and surface cover variables

- stronger relationships in the globally warmed background scenario
- variable influence in the night-time was significant for both the existing and warmed climate background
- sky view factor (SVF) showed the strongest relationship to MRT
- The geometric variables (SVF, FAR, and HRE) take precedence over the surface cover variables [PSF, ISF, GSF (green surface cover)].
- Whether the ground cover included vegetation or open soil had little or no effect.
- although within site variations with morphology and orientation was clear, there was no pattern evident in comparative sites in the study area.

3. ‘A "Local Climate Zone" based approach to urban planning in Colombo, Sri Lanka’

Incorporation of urban morphology (both geometric and surface cover), thermal and anthropogenic properties into a mapping protocol has significant advantages for climate sensitive and context specific urban planning. (Perera, 2015)

The current zoning plans for the city practice either a land use or activity based strategy.

Advantages of a mapped LCZ approach

- easy identification of critically stressed areas. (e.g. LCZ1 shows the highest intensity of UHI)

- highlight areas that could be preserved, thus avoiding an increase in local level warming. (e.g. LCZ2, LCZ3, LCZ8, developing to LCZ1 – could be avoided. An alternate way to develop these areas maybe to repurpose for more productive activities without changing much of the morphology. (Perera et al. 2013)

Flexibility in its interpretation and its application

- ‘value ranges’ defined in its classification [see (Stewart & Oke 2012)].

- The possibility of sub-classification of LCZs
  (generate sufficient heterogeneity and design flexibility to the urban fabric)

e.g. - The ‘’shadow umbrella” approach (see Emmanuel, 2005) is a good example of this built-in approach, where the block shape is consciously modified to enhance the climatic potential of the adjacent urban outdoors

Conclusions - ‘LCZ-based Zoning and lessons for the Tropics’

The system provides a protocol for rapid mapping and remains comparable across similar urban contexts. The benefit of such a system in data-scarce contexts of cities in the developing world is significant.

However some caveats are in order.

(a) Simplification of the climatic context

- While a LCZ-based planning approach provides a quick and cost-effective start, the danger is in the over simplification of the context, especially in using them as planning zones.

(b) limitations of a future zone specific, planning approach

- Incorporates geometric, surface characteristics together with thermal, radiative and metabolic value ranges in their selection.
- achieves characteristic morphology patterns, and the incorporation of climate characteristics within the selection.
- key limitation is that the simplification limits its ability to specify zone-specific future planning strategies

  (e.g. if zones are so demarcated as to highlight climatic peculiarities within cities, the necessary simplification of the system limits its ability to devise distinct guidelines for each zone)

(c) Implementation and Interpretation

- Interpretation of the inherent value ranges in a LCZ-based, zone-specific guideline could lead to difficulties in their application.

  e.g. - In the context of Colombo - where the density and building regulations are applied generally – specific application could be open to disagreement. The issue of sub-classification could also raise concerns as to; where and to what extent is sub-classes allowed? How will the values change? In terms of equity – who gets to exceed the norms and how are these defined?

The need for context specific knowledge from several tropical cities in this data-scarce yet rapidly developing region is emphasised. Such knowledge will enrich both the process of classification and sub-classification, thus enhancing its usefulness

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