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Towards climate embedded local planning in Sri Lanka to mitigate overheating: The case of Colombo.

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Title: Towards climate embedded local planning in Sri Lanka to mitigate overheating: The case of Colombo.

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Sri Lanka attracted a ripple of developments since the aftermath of a civil war and Colombo, the capital city, is undergoing an unprecedented development phase which could permanently alter its land cover and thus contribute to urban overheating. This can have severe consequences on human health and the environment. The planning and building regulations of Colombo did not seem to capture any sense of this imminent threat despite the availability of proven urban warming mitigation strategies in the literature. The study takes a pragmatic approach in identifying the barriers and opportunities of implementing urban climate (UC) action through expert knowledge and judgement.

The thermal comfort (UTCI) was calculated and mapped for metadata obtained from 20 stations throughout Sri Lanka for the past 25 years, and a strong trend towards extreme heat stress was identified in Colombo. This, along with an analysis of thermal comfort for a typical street in Colombo on a maximum buildable configuration, were included as aiding materials to probe rich insight from professionals during in-depth interviews. A thematic analysis of the interviews suggests the following as key challenges – lack of continuity of climate initiatives despite socio-political changes, lack of guided local research for UC, fragmented planning institutions, the attitude of authorities and public, political interferences and integration of climate policy initiatives in a third world country which face other socio-economic challenges.

Based on the above, the study suggests a practical course of actions that can be developed as a framework for successful integration of UC actions in the planning context.

Keywords

Overheating, urban climate, urban warming, climate knowledge in planning, climate-sensitive planning.

Originality statement. I hereby declare that this Master's dissertation is my own original work, does not contain other people's work without this being stated, cited and referenced, has not been submitted elsewhere in fulfilment of the requirements of this or any other award.	**Signature**

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Abbreviations:

AR – Aspect ratio

CDP-Colombo Development Plan

EW – East West

EEA – European Environment Agency

FAR – Floor Area Ration

HAP - Heat Action Plan

HW- Heatwave

LCZ- Local Climate Zones

NS – North South

RH – Relative Humidity

Sc- Scenario

UC – Urban Climate

UDA- Urban Development Authority

UHI – Urban Heat Island

UTCI – Universal Thermal Climate Index

UW- Urban Warming

1. Introduction

Urbanization and climate change are two significant global trends that are fundamentally interlinked. The increasing population and the subsequent urban development induce a complex change in the natural environment. The ambient temperature of cities is generally known to be higher than that of surrounding suburban and rural areas, which is well known as the Urban heat island effect (UHI) and is a well-documented issue (Oke, 1973; Emmanuel & Fernando, 2007; Emmanuel, 2011; Rosenfeld, et al., 1995). This, coupled with the increasing global temperatures and extreme weather events such as heatwaves, results in an urban overheating risk.

This is one of the serious problems that pose risks on human health, for instance, around 70,000 deaths in Europe were related to a major heatwave in 2003 (Stedman, 2004; Bhattacharya, 2003), and severe acute respiratory syndrome (SARS) was identified due to urban air stagnation in Hong Kong (Ng, 2009).

Lack of climate-responsive planning and haphazard development were identified as one of the main contributors to the above mentioned environmental and health ill effects. Thus, manipulating the 'urban form' in cities through planning and regulation to mitigate and adapting to the climate is fundamental (Mills et al., 2010), especially in rapidly developing cities. South Asian countries, specifically Sri Lanka, are growing at a rapid phase, due to the global economic competition and its strategic geographic location, which has resulted in enormous development pressure.

Colombo experiences more hotter days throughout the year, and this increases the risk of overheating due to unregulated development. Thus, there is an urgent need to capture climate-responsive actions in the local planning system.

1.1. Rationale

The skyline of Colombo-Sri Lanka is changing rapidly at an unprecedented pace, inducing several skyscrapers and mega-developments. Most of the developments are driven by socio-economic, marketing, demand for floor area etc. and is perceived as a real estate bubble. These developments often neglect which impacts the urban climate, mainly urban warming trends, which could lead to severe health and environmental hazards.

The urban planning guidelines and policy regimes in Sri Lanka have rarely addressed climate change, particularly at the urban neighbourhood level. The city planning guidelines, which are in effect now, were developed many years ago and are still being followed without responding to the current urban climate issues.

Hence, incorporating climate-responsive design strategies with ground-level development guidelines is a dire need to mediate the urban climate of rapidly growing cities like Colombo. Thus, 'how' to incorporate these in planning guidelines and policy regime is to be sought.

1.2. Aim & Objectives

The study argues that climate-sensitive planning is essential to manage the Urban Climate (UC) to reduce the risk of urban overheating. Regardless of compelling studies in identifying mitigating strategies, no action has been undertaken to regulate the built environment in this regard.

The research aims to understand the perceived importance of overheating issue in the local planning context of Colombo and comprehend a practical way of incorporating it effectively. The objectives are as follows:

- **Quantify the scale of overheating** in Sri Lanka due to climate change and urbanisation.
- Evaluate the passive **design strategies** for enhancing urban climate and mitigate overheating.
- Investigate the **current degree of implementation** of climate-sensitive design strategies in Colombo Development Plan (CDP).
- **Identify barriers and opportunities** to implement UC actions in planning.

- **Recommendations** for a practical course action in effective implementation of UC actions in the local planning context of Colombo.

1.3. Thesis Approach

The study for thermal comfort demands an interdisciplinary approach to "integrate physical, physiological, psychological, and social parameters" in helping planners to derive design decisions (Elnabawi & Hamza, 2019). Thus, this thesis uses abductive reasoning to understand possible interventions in implementing climate knowledge in planning and development. The study comprised three segments – the first and second segments are quantitative studies to understand the objective reality of urban overheating in Colombo – the results of which were used to aid the interviews in probing rich insights. The third segment is a qualitative study that attempts to understand the social construct of urban climate knowledge through policy and expert knowledge in Colombo.

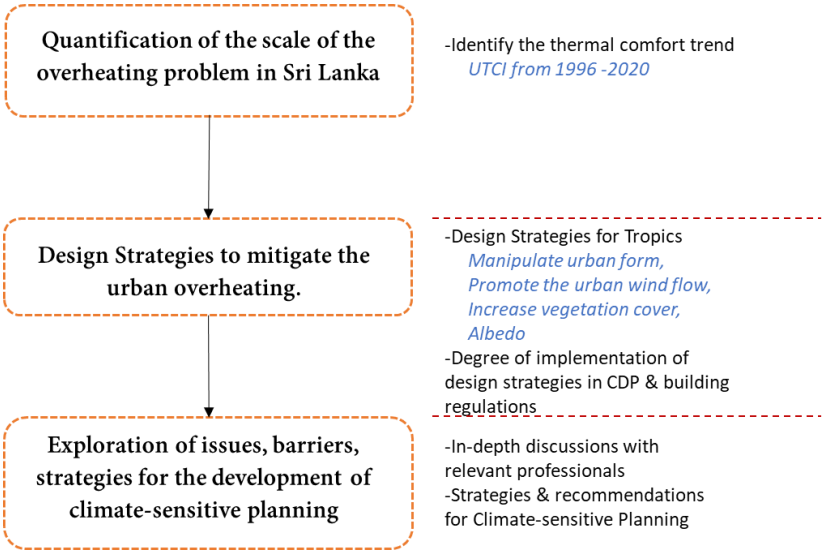


Figure 1. Segments of the Thesis

1.4. Thesis Structure

The thesis consists of five chapters:

Chapter-1 set the context of the issue and gives an overview of the thesis. Chapter-2 conveys a literature review for the design strategies and the planning context of Colombo. Chapter-3 presents the methodological framework and explains the methods and tools used to achieve the objectives. Chapter-4 presents the results of the three separate analyses and discusses them with regard to the aim of the research. Chapter-5 contains a summary of the findings, followed by recommendations for climate-sensitive planning in the context of Colombo.

2. Literature Review

This chapter lays the groundwork of suitable climate-sensitive design strategies for the tropics and presents the planning context of Colombo Sri Lanka. These were key in substantiating questions, aids, and props for the semi-structured interviews for the study.

2.1. Climate effect of urbanization

"Urbanization can influence climate change at local and regional levels" (Cao et al., 2016), some of which are reflected in disasters in urban areas such as floods, pollution, UHI etc. (Srivastava, 2021). Heat-related effects due to urbanization have become hot topics now.

2.1.1. Heatwaves

Heatwaves (HW) are prolonged periods of extreme temperatures associated with relative humidity and air pollutant concentrations (Lee and Painter, 2015). They are known for their health consequences, which are documented in developing countries but lacks research in developing countries such as South Asia, where the recurrent HWs effects cause severe distress due to urbanization and development agendas.

Well-known heatwaves that have caused devastating effects include 1995 HW Chicago, 1998 Shanghai, 2006 HW in California, of which the 2003 European HW caught the attention of the world, claiming 70,000 deaths (Tan et al., 2007; Robine et al.; Lemonsu et al.; 2015 as cited in Kotharkar & Ghosh, 2021). A study evaluating the impacts of a 2010 Indian heatwave in Ahmedabad, where the temperatures spiked to 46.8 C, revealed that the excess mortality contributed to 1334 excess deaths due to this heatwave (Azhar et al., 2014).

The Ahmedabad heatwave caused a stir amongst policymakers which led to the development of one the first Heat Action Plan (HAP) in South Asia (Knowlton et al., 2014). The strategies of this HAP included "building awareness amongst the community, initiating an early heat warning system and capacity building amongst health care workers" (Knowlton et al., 2014). Implementation of the HAP showed significant results and avoided around 2380 deaths since the implementation of HAP to 2018 (Hess et al., 2018).

2.1.2. UHI

The existence of “higher temperatures in urban areas than the surrounding rural areas is known as the Urban Heat Island (UHI) effect” (Oke, (1973). In the tropics, where the temperatures are warm throughout the year, UHI can worsen the air temperature and lead to an increase in cooling loads and have serious implications on health and air quality (Kotharkar & Ghosh, 2021).

UHI is induced by haphazard urbanization, compact built structures, asphalt roads, non-reflective, impervious surface materials, lack of vegetation, high anthropogenic activities, high energy consumption, and greater concentrations of air pollutants in urban areas (Elsayed, 2012; Nuruzzaman, 2015; Santamouris, 2015; Shaharuddin, Noorazuan, & Yaakob, 2009 as cited in Ramakreshnan, et al., 2018).

Further, it is understood that, even though there is a rich and diverse knowledge in UHI, there is a gap between knowledge and application of adaptation and mitigation approaches, which needs to be bridged (Giridharan & Emmanuel, 2018).

2.1.3. Outdoor Thermal comfort

Thermal comfort can be described as the physiological interval within which a human can operate or tolerate the environment (Lee et al., 2017) and can vary amongst people even in the same environment (Nikolopoulou, 2011). Macpherson (1962) identifies six elements affecting thermal sensation – “air temperature, air velocity, relative humidity, mean radiant temperature (physical variables), clothing insulation and activity level (personal variables)” (Lin & Deng, 2008 as cited in Djongyang et al., 2010).

In warmer climates, indoor thermal comfort is achieved mainly through air conditioning but at the expense of releasing waste heat to the environment. This adds heat stress to the immediate surroundings, affecting outdoor thermal comfort and dropping the efficiency of the air conditioning (Emmanuel, 2016).

2.2. Climate-sensitive design strategies to improve urban climate

Cities can be synthesised as ‘urban function’ and ‘urban form’ where ‘Urban form’ relates to the surface cover, the fabric and the city’s structure. This includes – the paving materials, building materials, vegetation cover, building form, solid-void ratio etc., all of which could be governed by the planning system (Mills et al., 2010).

Achieving thermally comfortable outdoor environments is very difficult in the tropics due to high humidity, poor wind movement and higher enthalpy (Emmanuel, 2016). Four approaches can be identified to mitigate urban overheating in warm, humid cities (Emmanuel, 2011; Perera, 2015).

- Manipulate urban geometry to shade.
- Promote the urban wind flow
- Increase vegetation cover.
- Increase thermal reflectivity (albedo) of urban surfaces.

2.2.1. Manipulate urban geometry to shade.

Academics and scholars have been studying the implications of urban form on local climate over the past few years. (Olgyay’s, 1963; Givoni, 1988; Knowles, 1981; Martins et al., 2014; Emmanuel, 1993 as cited in Emmanuel & Steemers, 2018).

A study in Colombo indicates that “wider streets with low-rise buildings and no shade resulted in the worst thermal comfort and narrow streets with tall buildings near the sea depicted more comfortable settings” (Johansson & Emmanuel, 2006). This variance in an urban setting can be understood through “Aspect Ratio (AR)”, which is the height of the building to its width (H/W). Though the deep canyons (high AR) provide shading from solar, they tend to trap the radiation and create negative effects (Erell, 2008). However, according to Sharmin et al. (2015 as cited in Giridharan & Emmanuel, 2018), “compact urban geometry with an aspect ratio between 2.4 and 3.5 can provide better thermal comfort”. Emmanuel (1993) has proposed ‘Shadow Umbrella’ that can shade larger areas of urban outdoors as a crucial strategy. These scenarios should be carefully studied and promoted by a set of design guidelines that foster shading (Emmanuel, 2006) in tropical cities like Colombo.

Though an emerging trend in understanding the synergy of urban form and climate is observed, the effect of shading through the urban form is not thoroughly explored to generalize the verdicts from one area to another (Giridharan & Emmanuel, 2018). Data required, analysis method, and interpretation into real-world planning application remain problematic at present (Perera & Emmanuel, 2018).

2.2.2. Promote wind flow.

Promoting airflow is a well-known strategy aiming for thermal comfort in the tropics and was perceived to be the most crucial (Emmanuel, 2015). "The most discomfort in tropics can be felt during the passing of the inter-tropical convergence zone twice a year, when the wind speeds are very low" (Emmanuel, 2011). This demands a ventilation strategy to promote airflow within the city. One of the best-case studies for such a planning method is demonstrated in Hong Kong's "Air Ventilation Assessment" (AVA) strategies (Ng, 2009).

Height variation in buildings promote ventilation, and taller buildings do not necessarily block wind movement (Chan et al. 2001 as cited in Perera, 2015). Further, different surface temperatures promote street-level ventilation (Yang and Li, 2009 as cited in Emmanuel, 2011).

2.2.3. Increase vegetation cover.

The benefits of green in microclimate are a long-recognized phenomenon. A 10% increase in green led to cool high-density areas of Manchester city by around 3º-4º C (Greater London Authoruty City Hall, (2016)). Emmanuel & Loconsole (2015) noticed that increasing green by 20% could lower surface temperatures by 2ºC. Shahidan et al. (2012) have demonstrated the possibility of lowering the outdoor temperature by 2.7ºC through vegetation and appropriate ground materials.

Having pocket parks (1000 sqm) can be more effective than larger ones. A park can influence its immediate temperatures up to 300 m of its surrounding (Ng et al., 2012; Giridharan et al., 2008; as cited in Giridharan & Emmanuel, 2018). Compared to a concrete wall, a green wall could decrease the surface temperature by 6°-10 °C). Although the effects of vegetation on street-level air temperature is unspoken, its impact on thermal comfort is substantial (Emmanuel et al., 2011 as cited in Perera, 2015).

Rantzoudi & Georgi (2017) discusses the appropriate arrangement of trees in an urban context to get the maximum benefit. Russ (2002) explains the sizes and position of trees and he recommends

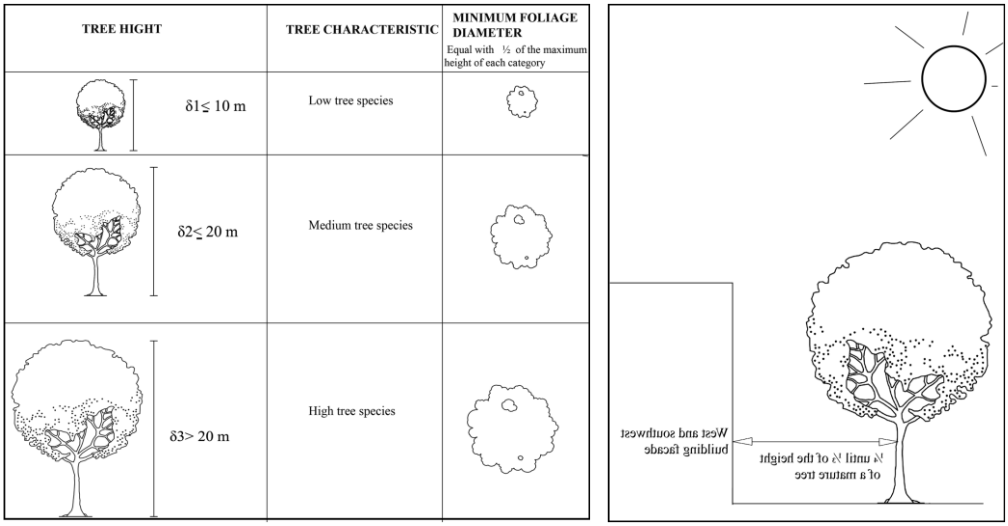


Figure 2: Trees, height, and diameter (left); Planting position of a tree (right) (Russ 2002 as cited in Rantzoudi & Georgi, 2017)

2.2.4. Increase thermal reflectivity (albedo).

Using high albedo materials contributes to mitigating the UHI effect and improves thermal comfort in outdoor spaces (Erell et al., 2014), especially in tropical cities where wind speed is low (Emmanuel, 2011).

A study by Priyadarsini et al. (2008) indicates that material with a low albedo can increase temperatures up to 2.5°C. Emmanuel and Fernando (2007) found that high albedo materials can cool the street canyon by 1.2°C in Colombo. Further, Erell (2008) states that the temperature of roof tiles can be reduced due to 'cool coatings' by 1.5°C for green and 10°C for black tiles. A study about cool pavements in Malaysia shows that porcelain tile over asphalt can reduce the surface temperature by 6.4ºC (Antiga et al., 2017 as cited in Giridharan & Emmanuel, 2018). However, Emmanuel et al. (2007) noted that though albedo enhancement is favourable in reducing air temperature, that may not necessarily improve thermal comfort.

Enhancing wind flow, use of vegetation and other shading strategies could be most effective approach to mitigate overheating in tropics. However, these strategies should be carefully

studied and applied to graphs the positive effects of different mitigation strategies while avoiding adverse effects of each other in the practical context.

2.3. Climate-sensitive Planning

This section is an overview on the governance of urban climate actions.

2.3.1. Urban governance for climate management

Every city has its own political, physical, and socio-economic characteristics that should be incorporated when analysing and forming climate policies. No single approach or single sector can deal with climate change. When assessing climate policy integration, one can easily fall into the *"everything matters"* trap (Ryan, 2015). Through a literature review on the climate policy environment, with particular focus on developing countries, Ryan (2015) recommends a framework of critical factors affecting climate policy integration. This includes:

- Local framing of the problem: addressing contextual (local) socio-economic concerns is more likely gain approval from local actors than climate goals, which are often thought to be long-term goals.
- Local government capacity: funds, information, organizational resources etc., are necessary enabling conditions.
- Political actors & factors: the will of political actors and stakeholders. Any policy can be backed or blocked by political actors and factors.

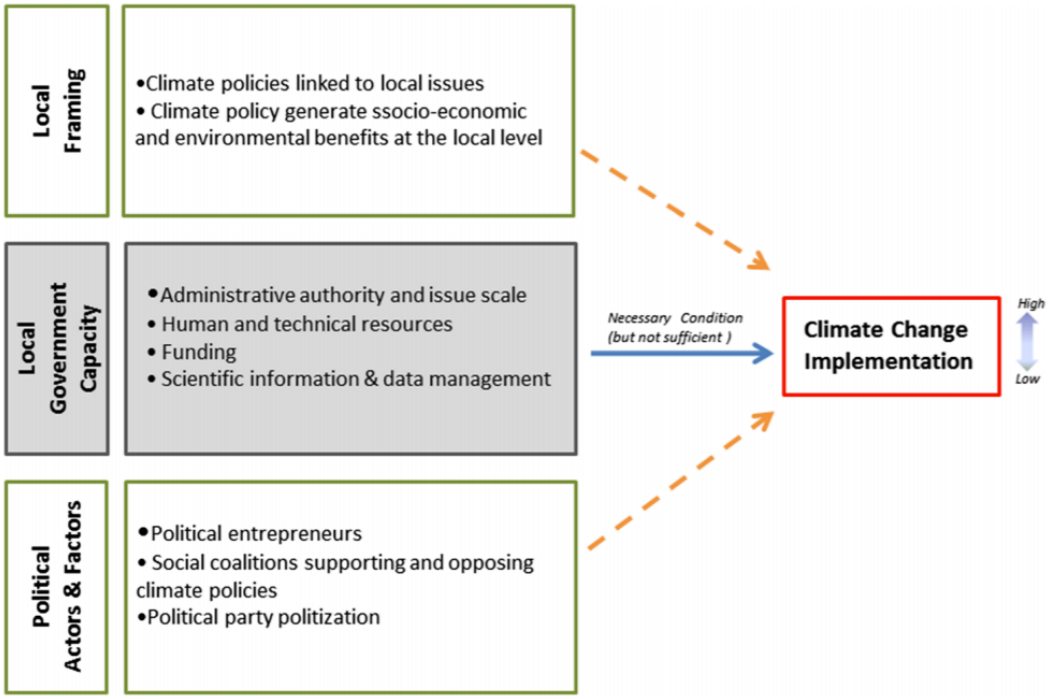


Figure 3: "Analytical framework: key factors affecting climate policy implementation" (Ryan, 2015,p 527)

Successful implementation of integrated mitigation and adaptation policies needs multilevel (horizontal & vertical) governance (Lee & Painter, 2015). In other words, governance amongst city administrations (horizontal) and amongst city government, NGOs, researchers, and other stakeholders (vertical).

One of the prominent institutions that can materialize these policies and actions recommended by international and national governments is the local government. (Huq et al., 2014, Bulkeley, 2010). When considering infrastructure and development, these policies are often translated into the local guidelines too, along with the national and regional guidelines.

2.3.2. Challenges on urban governance for climate management:

A global survey (2014 MIT – ICLEI), which included 350 cities in the study, found the following challenges on the urban governance of climate change:

- Lack of funding
- Completing priorities – health, housing, economic growth
- Integrating climate mitigation and adaptation into existing departments and functions.

- Lack of leadership from mayors, officials, and representatives of the governments.
- Diversity and fragmentation of the existing knowledge in climate. (Aylett & Alexander, 2014)

2.3.3. Planning strategies:

Climate knowledge is usually translated into adaptive strategies (to cope with the change) and mitigative strategies (to limit the ill effects). However, apart from mainstream air quality management guidelines, there is a lack of understanding in integrating climate knowledge into planning, one of the reasons being the difficulty of translating complex climate knowledge into policy (Emmanuel, 2016). Several urban climate mapping and analysis tools are being developed to assist planners and urban designers in formulating strategies. One such mapping system in classifying the local climate that is less resource-intensive is the 'Local Climate zone (LCZ)' based zoning approach.

2.3.3.1 Local Climate Zone (LCZ):

LCZ is an approach to urban climate mapping by classifying contexts by their main micro-climate features for climate-sensitive planning, developed by Stewart & Oke (Perera & Emmanuel, 2018). It allows a standardized description of land use and land cover while giving meaningful interpretations of a particular city, which can derive urban climate actions. Mapping through LCZ is relatively fast and allows easy identification of heat stress areas, but also captures surface cover, thermal and anthropogenic properties and thus is conceived as a comprehensive climate-based classification of zones. Thus, it is perceived as a promising approach for data-poor developing cities like Colombo (Perera, 2015).

Perera & Emmanuel (2018) present a well-developed documentation of LCZ for Colombo. Since the existing planning system of Colombo is based on a zoning system, LCZ could be easily integrated into it. Planners can easily identify the critically stressed areas and determine values for variable that regulate the current regulatory framework of Colombo such as – "minimum plot size, minimum width between building lines of a particular street, maximum permissible FAR, maximum plot coverage etc." (Perera, 2015).

However, no approach to integrate this sought of zoning is visible in the planning context of Colombo.

2.4. Sri Lankan context

Figure 4: Location of Colombo in Sri Lanka, (source: http://www.asia-atlas.com/sri-lanka.htm)

Sri Lanka is an island, Colombo (6.9271° N, 79.8612° E), closer to the equator with tropical climate usually hot and humid, where the solar altitude is high throughout the year and has no seasonal changes except the monsoonal variation.

Sri Lanka's climate has been already changed, and recently more attention on the temperature rise. Studies on trends analysis of meteorological data indicate that atmospheric temperature increases gradually throughout the country (Basnayake, 2007) and the warming trends have become faster (Ministry of Mahaweli Development and Environment, 2016).

Colombo is the commercial capital of the country, which is in the western coastal belt. The outdoor environment in Colombo is deteriorating due to rapid developments, mostly haphazard in nature, and is affected by the UHI issue experiencing the negative consequences of UW which correlates with land use land cover change (Emmanuel, 2004, 2006, 2011, 2016; Perera, 2015).

As to manage this warming trend, incorporating climate embedded local planning is essential. The current planning regime of Colombo Sri Lanka is not yet addressed to mitigate the urban climate issues (Perera & Emmanuel, 2018).

2.4.1. Current Planning Context of Colombo

2.4.1.1.Urban Development Authority – Colombo

Urban Development Authority (UDA) is the existing governing body in Colombo which regulates many planning policies. A summary of planning initiatives of Colombo Sri Lanka is synthesized as follows:

Planning Initiatives – Colombo

1921	First City plan by Sir Patrick Geddes	Make Colombo the '**Garden City of the East**'.	
1949	Abercrombie Plan' by Sir Patrick Abercrombie	Covered the Colombo Metropolitan Region as a whole and emphasized **decentralization** of the city's activities and creation of satellite towns around Colombo.	
1978-1985	UNDP Assisted Colombo Master Plan & Colombo Development plan	Recommended shifting of from Mono-Centric to Poly-Centric City Development and shifting of the Administrative Capitol to Sri Jayewardenepura. Laid foundations for implementing zoning and building regulations in the city.	
Gam Udawa – Village Reawakening			**Political Agenda**
1998	Colombo Metropolitan Regional Structure Plan (CMRSP)	Envisioned development of the entire Western Province as a Single Metropolis	
Mahinda Chinthana, Vision for the Future			**Political Agenda**
1999	City of Colombo Development plan	As an amendment to the Colombo City Development Plan 1985. It was prepared based on the Core Area Plan of CMRSP (1998) hence, follows its planning guidance given for the City of Colombo	In-effect now
2004	Western Region Megapolis Plan	To develop a cluster of urban centres connected with modern transportation network to the Colombo Core	
2008	City of Colombo Development Plan (Amendment)	To develop a cluster of urban centers connected with modern transportation network to the Colombo Core.	

Figure 5: Planning initiatives of Colombo, (Urban Development Authority, 2019)

UDA strategy for the planning and regulation of the city can be grouped under four major areas:

1. Zoning Plan and Planning regulations
2. Density regulations
3. Building regulations
4. Development guide plans (DGP's) (UDA, 2018)

Ideally, the ground-level development guide should capture the strategies for effective implementation. The building regulations which are effective now (2008 Amended version) were reviewed (with the knowledge and working experience of the researcher) in terms of incorporation of climate-sensitive design strategies (as discussed in 2.2) and summarized in *Table 1*.

Components	Description
Open space	Certain Green spaces are demarcated in the CDP (eg: Viharamadevi park, Belleville sanctuary etc.) while there are specific development guides for one or two areas (eg: Independence square).
Greening or vegetation	There are no tree surveys/ tree protection plan or any vegetation proposal in the CDP.
urban geometry	No direct guide with regards to urban geometry in regulating urban warming. However, the urban geometry is governed by C forms – a matrix that governs the development potential of a plot (refer Appendix 06)
Block orientation	No specific orientation guidelines. The developers tend to orient the building to gain maximum land use, rather than considering cooling benefits
Development height profile	The C forms specify what height can the building go up to which is based on the plot size. The height profile of buildings are limited by zones too (eg: height limit for sea front development zone)
breezeway/ventilation	The present plan doesn't identify any breeze corridors.
Cool materials	Not defined in the documents

Table 1: Design strategies in Building regulation of Colombo based on (Source: CDP 2008 amended version)

A few regulations indirectly contribute to regulating the urban climate (Eg: density control or FAR limit positively or negatively affect the wind flow). However, no conscious effort has been made in incorporating design strategies and climate knowledge into the existing system.

2.5 Research gap:

The literature identifies four main design strategies for mitigating urban heat in the tropics and an urban climate-friendly planning guide that could easily be adapted for data poor countries such as Sri Lanka. Regardless of the reality of an imminent overheating threat, and despite recommendations of scholars on effective Urban Climate mitigative actions, the planning and building regulations of Colombo haven't captured any of these.

'How' to incorporate these strategies in planning has not been adequately explored in the tropics, especially Colombo. It is very easy for one to fall into the "everything matters" trap when integrating climate policies. Thus, this should be investigated thoroughly, with a focus on the local socio-economic context.

3. Methodology

The research was guided by the research onion developed by (Saunders et al., 2019) to ensure proper data and analysis methods.

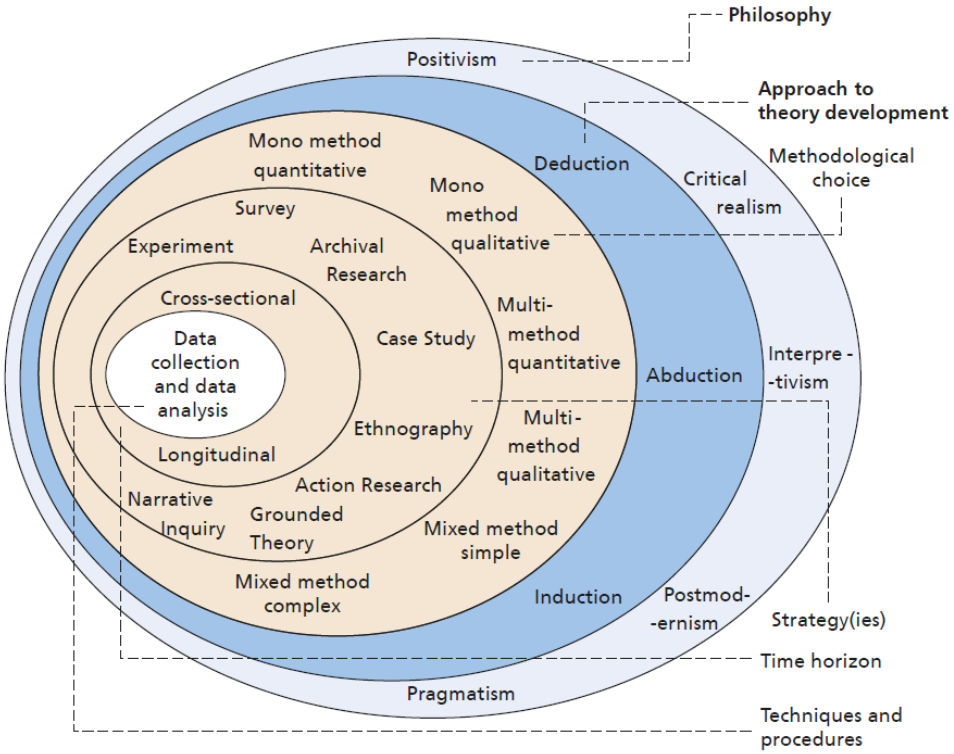


Figure 6: Research onion, Source: (Saunders, et al., (2019)

The research philosophy, approach and strategy were designed to address the following research question:

> **"How is the importance of Urban climate actions perceived in the local planning context of Colombo and how can this be incorporated effectively?"**

3.1. Research Philosophy

The ontology of this study is that reality is constantly negotiable and based on the practical outcomes of concepts or ideas. Thus, the research is scrutinized through a lens of pragmatism and aims on the practicality, i.e. "what works", rather than the ideal notion of what is considered "true" or "real" (Frey, 2018).

Epistemologically, the study is positioned towards a pragmatic interpretivist approach – the aim is to understand the socially constructed policy through in-depth interaction of the researcher and subject, but through quantified results, which acts as probes and aiding material to gain rich insights.

Thus, the research question was approached with an aim to understand the underlying challenges and barriers and thus contribute to a practical solution in integrating them. The solution relies on Professional experience as "evidence" (data) using thematic analysis (qualitative analysis) to identify the flaw or gap in integration.

Axiologically, although the researcher has attempted to be as objective as possible during interviews and thematic analysis, the reality finds that the author's values could have influenced the study due to the nature of qualitative analysis. Accordingly, any interpretations should regard that the author has had 5 years of experience as a professional architect in dealing with planning authorities in Sri Lanka.

3.2. Research Approach

The study utilizes largely inductive, but also deductive approaches, to tackle the above research problem. Hence, it can be determined as an 'abductive approach' as it combines both deductive and inductive approaches. (Suddaby, 2006 as cited in Saunders et al., 2019, pg. 155)

Van Maanen et al. (2007 as cited in Saunders et al., 2019) says that abduction begins with reflection of a 'surprising fact'. The 'surprising fact' that endorsed the abductive approach was

> *"Lack of Urban climate mitigative strategies in the Sri Lankan planning documents, despite Urban overheating being an inevitable reality and the fact that sufficient literature has been developed in this regard"*.

The research question, guided by in-depth semi-structured interviews of professionals, led to inductive reasoning, which will allow meanings to emerge and help identify patterns and relationships of the social construct of the planning landscape.

3.3. Research Method

The objectives of the research were tackled with multiple methods, as described in Table 2.

Objective	Method of achieving the objective	Data sources
1. **Quantify the scale of overheating** in Sri Lanka due to climate change and urbanisation.	**-Meta data collection & analysis** -Calculate Thermal comfort (using RayMan) and map thermal comfort trend (in GIS) and recognize the change	Meteorology Department, Colombo Sri Lanka
2. Evaluate the passive **design strategies** for enhancing urban climate and mitigate overheating.	-Detailed **Literature review** on urban climate (UHI, heat wave, thermal comfort) climate-sensitive design strategies for Tropics, determine the best resolutions for the Sri Lankan context.	Scholarly articles, Publications, Journal Articles, Urban planning documents.
3. Investigating the **current degree of implementation** of climate-sensitive design strategies in Colombo Development Plan (CDP).	**-Evaluation of Colombo Development Plan 2008 Amendment.** **-In-depth discussion** with urban professionals	**-City of Colombo Development Plan** 1999,2008 **(Urban Development Authority-UDA)** **- Professionals**
4. **Identify barriers and opportunities** to implement UC actions in planning.	- **Semi-structured interviews** with urban professionals in the industry to bring insight that are not documented officially. (6 personals)	**-Professionals**
5. **Recommendations** for a practical course action in effective implementation of UC actions in the local planning context of Colombo.	-Synthesis from above research findings	**Synthesis from research findings**

Table 2: Objectives & methods

To understand the reality of overheating in Sri Lanka, quantitative methods were used to quantify the overheating issue and thermal comfort according to the current planning context.

A qualitative research is associated with the interpretive philosophy which is inclusive of socially constructed meanings of the phenomenon (Saunders et al., 2019). The same was

utilized to understand the barriers and opportunities to integrating climate sensitivity in planning, with focus on the building regulations.

3.4. Research Strategy

The strategy to tackle the research question was approached in 3 parts:

- To understand the threat of overheating, Quantifying the overheating issue in Sri Lanka – to exhort the timely requirement of incorporating UC action in planning.
- To probe the interviewees, a specific street was taken, and the thermal comfort was calculated for the maximum possible FAR for the street.
- Thematic analysis of semi-structured interviews – To understand the social construct of integrating climate strategies to planning context of Colombo.

3.4.1. Quantify the scale of overheating

3.4.1.1. Data Collection

The study collected historic meta data from 20 stations from the Department of Meteorology - Colombo in Sri Lanka for the period of 1996-2020. Although the research intended to collect data for the past 30 years, there was no adequate data for the years before 1996. The monthly maximum and minimum temperature, relative humidity (RH) and wind speed for the past 25 years were collected for analysis.

3.4.1.2. Data analysis

Maximum temperature and minimum RH was considered for the analysis of the hottest month. Minimum temperature and maximum RH was considered for the coldest month. The data set was evaluated and found out that 15 stations out of 20 reflected that the hottest month was April. Similarly, the coldest month in 17 stations of 20 was January.

A study indicates that the most uncomfortable months is the period between March to May since the air temperatures are at highest, with relatively low wind speed and high RH (Emmanuel & Johansson, 2006). As such 15th April at 13 pm (solar elevation is high at this time) was taken for thermal comfort trend analysis through Rayman Pro software.

3.4.1.3. Rayman Pro

RayMan is a software "developed to calculate short wave and longwave radiation fluxes affecting the human body" by Matzarakis et al. (2007). It is known to deliver decent simulation outcomes for radiation flux densities and thermo-physiologically significant assessment indices (Matzarakis et al., 2010).

3.4.1.4. Thermal Comfort Indices for this Study.

Universal Thermal Climate Indices (UTCI) is considered one of the comprehensive indices for calculating heat stress in outdoor environments. (Blazejczyk, 1994 as cited in Zare et al., 2018). Even the slight variations in the intensity of weather stimuli are captured (Blazejczyk et al., 2012) and is an opportunity for more suitable human-biometeorological assessment (Urban & Kyselý, 2014).

There are ten groups of UTCI equivalent temperatures varying from severe cold stress to severe heat stress (Zare et al., 2018), which are depicted and compared with the other indices in *Figure 7*.

Comparing thermal perceptions in various bioclimatic indices.

Thermal perception	Indices				
	UTCI	WBGT	SET	PMV	PET
Very cold[1] (Extreme cold stress[1,2])	< -40			-3	<4
(very strong cold stress[2])	-40 to -27				
Cold[1] (Strong cold stress[1,2])	-27 to -13			-2.5	4-8
Cool[1,3] (Moderate cold stress[1,2]/ Moderate Hazard[3])	-13 to 0		<17	-1.5	8-13
Slightly cool[1] (Slight cold stress[1,2])	0 to +9			-0.5	13-18
Comfortable[1,3] (No thermal stress[1,2]/ No Danger[3,4])	+9 to +26	<18	17-30	0	18-23
Slightly warm[1] (Slight heat stress[1])				0.5	23-29
Warm[1, 3,4] (Moderate heat stress[1,2]/ Caution[3,4])	+26 to +32	18-23	30-34	1.5	29-35
Hot[1, 3,4] (Strong heat stress[1,2]/ Extreme caution[3,4])	+32 to +38	23-28	34-37	2.5	35-41
(very strong heat stress[2])	+38 to +46				
Very hot[1, 3,4] (Extreme heat stress[1,2]/ Danger[3,4])	> +46	28-30	>37	3	>41
Sweltering[4] (extreme danger[4])		≥30			

[1] PET and PMV [2]UTCI [3]SET [4] WBGT

Figure 7: Comparison of thermal perceptions in various indices (Zare, et al. 2018 based on International Union of Physiological Sciences-Thermal Commission, 2003)

3.4.2. Design strategies to mitigate the overheating issue.

Chapter-2 identifies four main design strategies to mitigate the overheating issue. As such, design parameters: *aspect ratio, vegetation, wind flow and albedo,* were experimented with RayMan modelling (as to get tangible evidence of what literature says) for favourable microclimate configurations, with reference to development guidelines of the CDP.

Pilot evaluations were done on the urban configurations based on the CDP. Scenarios (modified from the base model) were modelled with 6m road width and aiming at a maximum development potential (max FAR) for a 400 sqm plot.

3.4.2.1.Scenario developments for RayMan simulation

Different scenarios were tested to FAR plot coverage according to guidelines a model was made. Aspect ratio, incorporation of trees, albedo and street orientations were defined for RayMan simulations as given in *Table 3*. Including the base case, five scenarios were developed and simulated to find out the better case suitable for Colombo as formulated in *Table 4*.

Street	6m width and 200 m length, both North-South and East-West orientation streets were considered for RayMan modelling.
Tree selection	6m height, 4m crown diameter trees were placed at 4 m intervals (zig zag). Russ (2002) recommends the minimum of 2.4m and more than 5m height tree is suitable for urban context (Rantzoudi & Georgi, (2017).
Aspect Ratio	In general, skyline of Colombo is low specially in residential and mix development zones. Aspect ratio is mostly below 1. As such 0.5 and 3 aspect ratios are defined for base case and other scenarios, respectively.
Albedo	Wider use of material in Colombo are concrete and cladding. As such 0.2 albedo for the base case and 0.5 for other scenarios were defined.

Table 3: Different parameters for simulations.

Base Case	Orientation	Aspect Ratio	Trees	Albedo	Time of simulation
Base Case	E-W	0.5	No trees	0,2	1 PM
Scenario 1	E-W	3	*6m height, 4m crown diameter at 4 m intervals placed at zig zag pattern*	0.5	1 PM
Scenario 2	N-S	3		0.5	1 PM
Scenario 3	E-W	3		0.5	5 PM
Scenario 4	N-S	3		0.5	5 PM

Table 4: Different scenarios for RayMan simulations.

For the RayMan Pro inputs, meta data of air temperature, relative humidity, wind speed and personal variables were used, and other factors kept with default values. RayMan simulation interface is given in *Appendix 01*.

3.4.3. Exploration of barriers and opportunities – Interviews

3.4.3.1. Semi-Structured interviews:

Semi-structured interviews are a valuable qualitative method that explores subjective viewpoints (Flick, 2009 as cited in Evans, 2017) and allows in-depth inquiry into people's experiences. Thus, this method was selected to bring the insight out from experienced professionals. Unstructured interviews often deviate from the focus area, whereas in structured interviews the researcher has a set of specific questions that are to be investigated (Bryman, 2012). Semi-structured interview is flexible – allows new ideas and at the same time framing the focus areas, hence was deemed to be suitable.

One-to-one online interviews were done owing to COVID-19 restrictions, which allowed easy access to the interviewees. Each interview was around 60-90 minutes.

3.4.3.2.Selection of interviewees:

The quality of data depends on the interviewees. Since the study focused on rich insights, more focus was given on selection of appropriate interviewees rather than the quantity. Hence, care was taken to identify experienced professionals who have contributed in shaping the planning landscape of the built environment in anyway. To minimize bias, professionals from architecture or planning background who were involved in influencing Colombo's planning landscape were selected. *Table 5* presents a summary of analysis of the participants. As per discussion in *Section 3.4.3.4* only five interviews considered for analysis.

Description	AC1	AC2	PR1	PR2	AD1	AD2
Profession	**Chartered Town Planner,** Academic, Professor involved in climate change adaptation plan in Sri Lanka	**Chartered Town Planner.** Academic, Professor from social background	**Chartered Architect, Chartered Town Planner.** Managing director at one of the largest urban design practices in Colombo	**Chartered Architect.** Managing partner at a multi-disciplinary Consultancy Services in Colombo	**Chartered Architect, Chartered Town Planner.** Administrative, former Chairman @ a Regulatory body.	**Chartered Town Planner.** Director General at a Regulatory body.
Years in industry	30+	15+	30+	25+	20+	30+
Worked in authoritative administrative position	Yes	No	Yes	No	yes	yes
Professional with investor relationship	yes	No	yes	yes	yes	yes
Worked with national organization which advocate climate	yes	Yes	yes	No	yes	yes
Highest academic qualification	PhD	PhD	M.Sc.	M.Sc.	PhD	M.Sc.
Involved in approving development plans	yes	No	yes	No	yes	yes
Involved in creating and promoting development plans	yes	No	yes	yes	yes	yes
Investor relationship-Practical application of development plans	No	No	yes	yes	No	yes

Table 5: Selection of interviewees

3.4.3.3. Structure of interviews:

The development of interview questions requires knowledge of both theory and practical context of urban climate and planning. The questions were mainly open ended or probing in nature and are focused on the existing planning context and urban climate in Colombo. They were classified into four sections:

- Investigating current planning context of Colombo – discussing the key focus, challenges of existing development plan (these questions were developed to make a common ground for the discussion).

- Identifying overheating trend in Sri Lanka – discussing thermal comfort trend maps and graphs of other cities (derived from the researcher)
- Climate sensitive design strategies in planning – checking whether it is incorporated in existing planning.
- Implementation of design strategies in planning.

The questionnaire for the interviews is attached in Appendix 02.

3.4.3.4. Analysis of interviews:

Thematic analysis:

Thematic analysis is a popular method of qualitative analysis that explores insights through patterns of meaning (themes) that occur around a data set, by systematically grouping and organizing it (Braun & Clarke, 2012). Since this allows meaningful insights to emerge regarding the research question being explored, this method was deemed suitable for the study.

Numerous patterns could be identified across any data set. However, patterns in relevance to the research question is important.

Since Aronson (1995)'s attempt on outlining a pragmatic view of thematic analysis, several methods have emerged on how to do a proper thematic analysis that could be accepted amongst researchers. This study follows Braun and Clarke's (2006 as cited in Braun & Clarke 2012) six phase approach to thematic analysis that is outlined as follows:

Six phases of Thematic Analysis	Summary of the process
Familiarizing Yourself with the data	The interviews were recorded, transcribed, read, and re-read before attempting to code. Notes were made on potential interests in strategies, barriers and intended meanings during the recording of data. The whole process is iterative in nature and by the end of 5 interviews, the author was considerably informed regarding the data. This determined that the data was saturated in the 6th interview and could lead in repeated codes. Hence, only interviews of only 5 participants were considered for analysis.

Generating initial codes	Codes acts as a label for meanings. Potential actions, researcher's interpretation, participants languages etc. were used for identifying explicit, latent, and semantic codes. A common criticism regarding coding is that the fragmentation of data may lose its context (Coffey and Atkinson 1996, as cited in (Bryman, 2012). Thus, sentence by sentence approach to coding was avoided. The coding process was started from the second interview itself and was attempted after each interview.
Searching for themes	When looking for themes Ryan and Bernard (2003 as cited in Bryman, 2012) recommended looking for repetitions, indigenous expressions, metaphors and analogies, transitions, similarities, causal connectors, and missing data. Recommendations for more detailed plans, fragmentation of institutions, political barriers etc. were repeated by all participants and was relatively an easy theme to generate. The detailed coding is attached in *Appendix 03* Patterns between codes were identified which led to sub-themes. Certain codes had to be disregarded since it was not relevant to the research question, eg: codes regarding transport infrastructure and traffic of Colombo.
Reviewing potential themes	The text was re-read and verified whether the codes represented the intended meanings. Care was taken not to interpret meanings out of context. Moving to and forth between codes and themes, codes were grouped to similar ideas and relevance to the research questions. For example, the lack of comprehensive building regulations, the need for neighbourhood level planning, the need to move away from single entity planning, etc. all indicated the need for a detailed planning guide and subsequently led to a theme.
Defining and Naming themes	This phase included defining similar concepts, merging subthemes, grouping and codes to under themes. Codes were grouped and re-grouped to fit specific ideas. For example, under settlement, vulnerability of the urban poor etc. were coded under inclusive planning, and importance of social and economic factors was coded under "balanced planning". Later these ideas, along with similar ideas, were sub-

	themed as “supportive policy integration”. A metaphor from the interview “Bread and butter is more important” was used to create the name of sub-theme – “Bread and butter vs. roof and shelter” to indicate the debate between primary policy and supportive policy integration of climate policies,
Producing the report	Writing of report was done from an early stage and this also helped to organize ideas. The report is presented and discussed in the next chapter.

Table 6: Approach to Thematic analysis

The above iterative process was made easy using ***NVIVO-12*** pro software, which enabled the grouping and re-grouping of hundreds of codes to achieve a coherent set of themes that make sense.

4. Results & Discussions

This chapter presents the results of initial assessments and the thematic analysis of in-depth discussions. Firstly, the results of quantification of overheating issue in Sri Lanka is presented. Secondly, the results of design strategy modification of a typical street is presented. Thirdly, thematic coding of the in-depth discussions is presented.

4.1. Quantification of the scale of overheating issue in Sri Lanka.

4.1.1. Thermal comfort trend in Sri Lanka.

A thermal comfort trend for the hottest and the coolest months in Sri Lanka are presented in *Figure 8* & *Figure 9* for the for the past 25 years (1996-2020).

(The maps for all the years and individual thermal comfort trend graphs for all 20 stations at the hottest and the coolest months are given in *Appendix 04* & *Appendix 05*.

The trends will be discussed with the aid of UTCI indices illustrated in Figure 7.

4.1.2. Thermal comfort trend in the hottest month- (April)

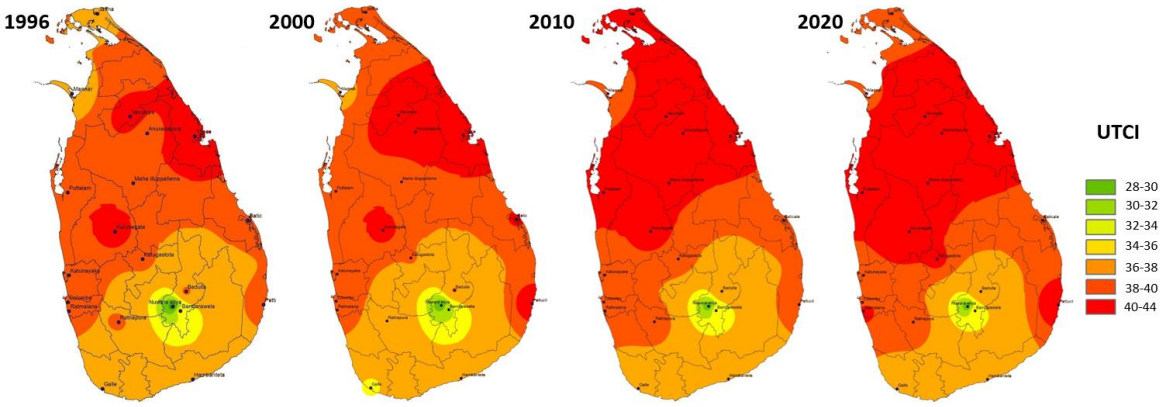


Figure 8. Thermal Comfort Trend- Hottest month (April)

UTCI was calculated for all 20 stations in Sri Lanka in 1996-2020 and a clear trend towards extreme heat stress was observed in almost all the stations, except the central part of the country. Especially the entire northern region (Jaffna, Vavuniya, Anuradhapura) and the

Eastern region (Trincomalee, Pottuvil) demonstrate ***very strong heat stress*** between 40-44°C. Further, the Western region (Colombo, Ratmalana), which was under ***moderate heat stress*** also range under very strong heat stress in 2020. However, though the met data in the southern part show high air temperature (Ta), ***moderate heat stress*** was observed in terms of thermal comfort; this could be interpreted that the reason is high wind speed compared to other regions.

In the year 1996, only three stations, namely, Vavuniya, Trincomalee and Kurunegala, ranges between 40-44°C. But in the year 2020, half of the stations ranges in ***very strong heat stress*** and the entire country has passed the threshold of thermal comfort.

4.1.3. Thermal comfort trend in the coolest month – (January)

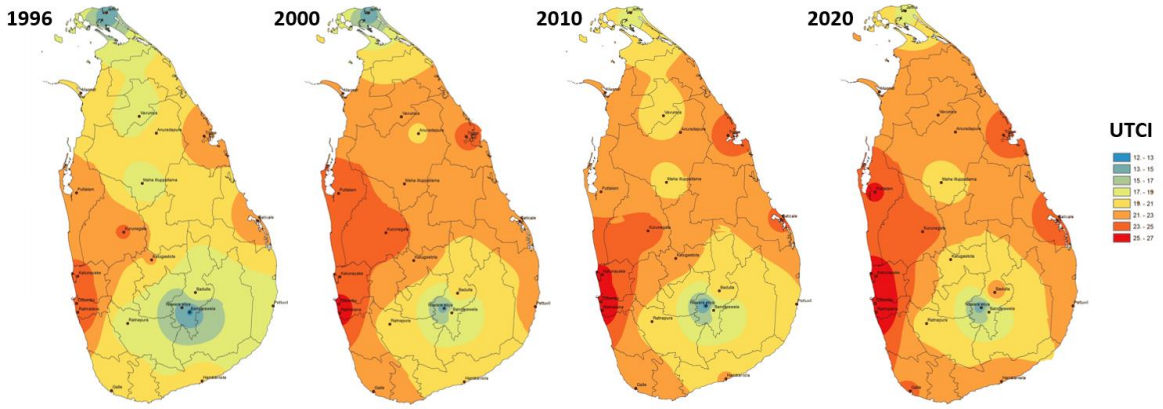


Figure 9: Thermal Comfort Trend-Coolest month (January)

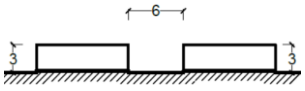
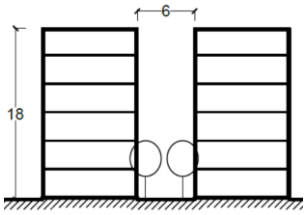
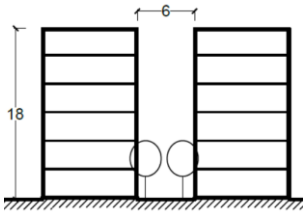
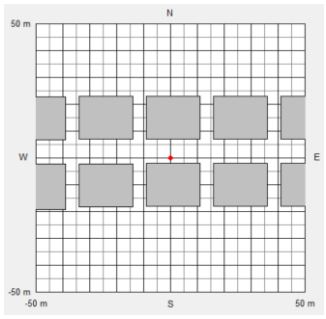
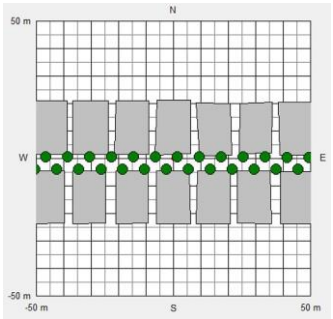
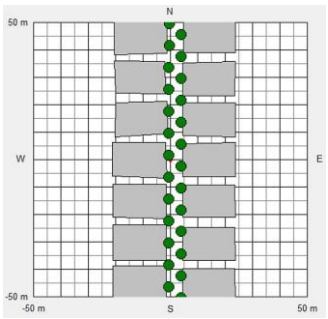
The maps suggest that the coolest month (January) is getting warmer throughout the years, with only the central part of Sri Lanka remaining at 18°C range. In 1996, almost the entire country ranged between 11-25°C, which depicts ***no thermal stress***. Northern region city - Jaffna, and central region cities - Nuwara-eliya and Bandarawela vary between 12-15°C. However, in 2020, Colombo, Katunayake, Ratmalana and Puttlam – the western region cities are moving to ***moderate heat stress***. The rest of the country also hovering towards upper ranges of thermal comfort.

Discussion

An increasing trend in thermal discomfort was noticed. The hottest month is getting hotter, and even the coolest months depicts a reducing number of cooler days. In other words, the entire year shifting towards a discomfort range for the whole country, except the hillside. A reason for this could be interpreted as the land-use land-cover changes during the last 30 years in the Colombo Metro-Region (Emmanuel, 2004), which indicate a peculiar development, in other words, urbanization. The urbanization rate in 2020 is 18.71% (Statista, 2020), and from 2001-2019 Sri Lanka lost 28.7% of its tree cover (Global Forest Watch, 2020). Hence, the need for timely climate sensitive planning and design strategies to mitigate urban overheating issues is vital.

4.2. Design strategies application with RayMan

The base-case and four other scenarios were simulated in RayMan and the thermal comfort was calculated using UTCI. The street sections, RayMan model and SVF for developed scenarios are demonstrated in the *Table 7*.

	Base case	Scenario 1& 3 EW street	Scenario 2& 4 NS street
Section			
RayMan model			

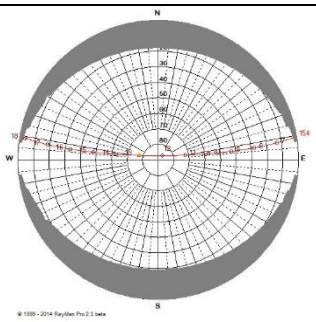
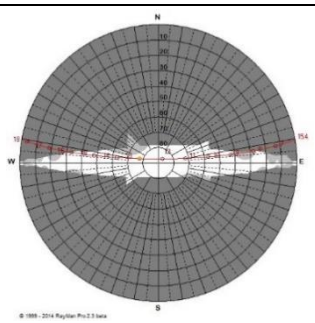
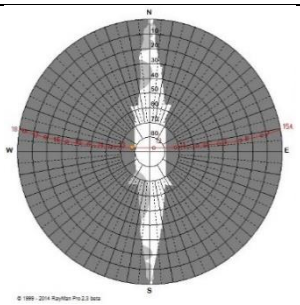
Sky view factor			
			
	SVF=0.817	SVF=0.201	SVF=0.199

Table 7: RayMan simulation for different cases

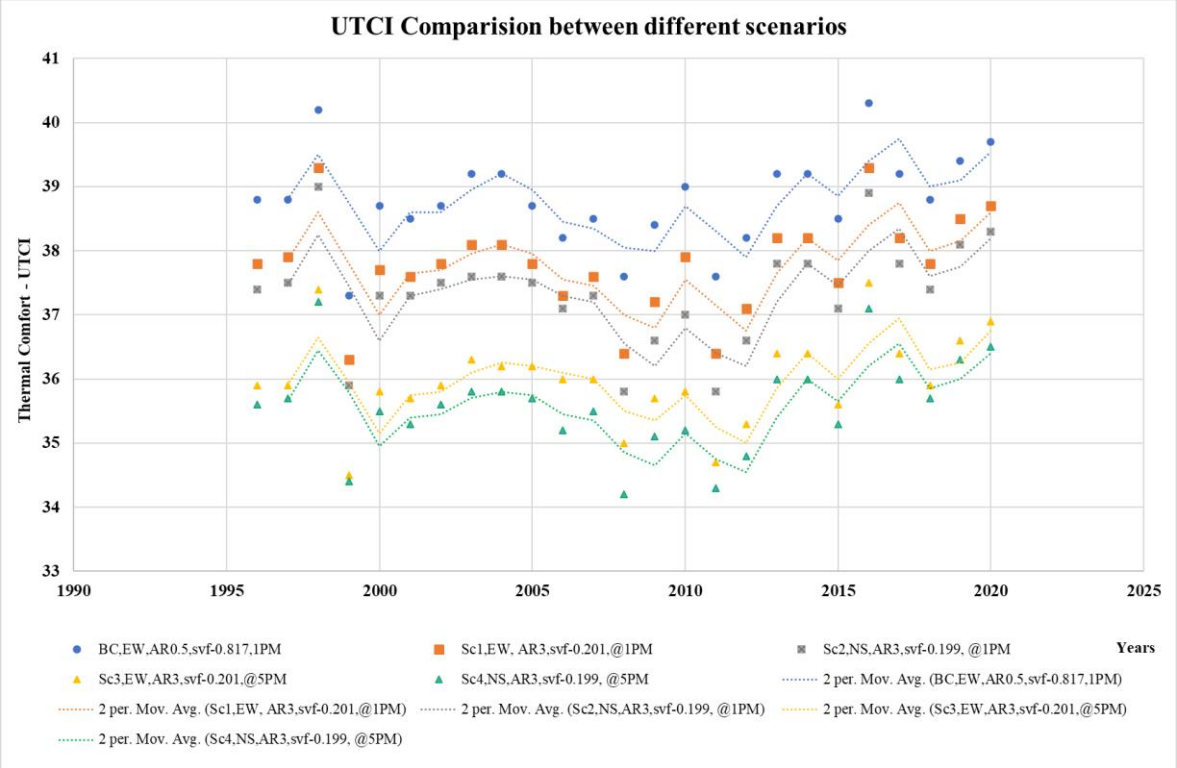


Figure 10: UTCI Comparison between different scenarios

Figure 10 presents the UTCI comparison between different scenarios. UTCI values on the hottest day can be explained due to high temperature, high RH and relatively low wind speed. The base case scenario obtained the maximum values of UTCI between 38-40 °C, which shows ***very strong heat stress***. And other scenarios followed the same pattern over the years but showed a slight improvement; Sc1 & Sc2 ranges between 37-38 °C and Sc3 & Sc4 ranges between 35-36°C till the year 2013, which belong to ***strong heat stress*** conditions. However, after 2013, a significant increasing trend was observed, which again

leads to a very strong heat stress. It should be noted that a moving average is used to smooth out the irregularities and to recognize the trends easily.

Sc1 & Sc2 show slightly better thermal comfort than the base case, with an average value of 0.8 °C and 1.1 °C, respectively. Further, Sc2 has better performance than Sc1 average value of 0.3°C. Sc3 & Sc4, which were simulated at 5 pm show noticeable thermal comfort than the base case, showing an average value of 2.7°C and 3.1°C, respectively. However, Sc4 showed the best performance out of all scenarios ranging between 34-36 C, showing an average difference of around 3°C than the base case.

Discussion

The thermal comfort of an urban street could be regulated by determining the amount of solar radiation and sky visibility through urban form, shade, and street orientation. This section investigates the optimum choices of urban form, trees based on sky view factor incorporating albedo to mitigate the urban overheating issue.

EW street is continuously exposed to solar radiation during the day, whereas NS street receives solar radiation in different parts at different times and thus, shows a slightly better performance than EW street. However, despite the orientation of the streets, it is complicated to achieve a thermally comfortable range at noontime, as shading the street is very difficult.

Higher solar altitudes (1 PM) has not shown considerable improvements in thermal comfort, despite the combination of appropriate design strategies. Hence measures could be taken to advise avoiding outdoor working at noontime to prevent the consequences of overheating.

Both aspect ratio and tree canopy cover determine the SVF. When the aspect ratio was increased, a decrease in the range of UTCI was observed. This is due to high H/W ratios reduce the SVF and provide shading to streets while cutting down the solar radiation.

Even though the instinctive strategy is to increase shade through vegetation and aspect ratio while reducing the SVF to mitigate overheat during the day, these configurations should not entrap the heat during the night. If the heat is trapped within the canyon, this will negatively affect the air temperature of the next day (Erell, 2008).

Since the case considered a 6m width (narrow) street, large trees or tree in the median strip cannot be incorporated. But for wider roads, tall trees with larger canopies could be considered to mitigate overheat as Russ (2002) recommends trees more than 5m height gives better thermal comfort at urban context. Again, designers should ensure that trees do not block the wind and lead to stagnation in the streets. Tree planting patterns and intervals that provide shade on a larger surface area for a more extended period should be considered when designing and planning streets.

Moreover, in scenarios, the high albedo was considered for simulations. This is challenging to apply in the real world as lighter colours in the buildings and roads lead to an uncomfortable level of glare (Emmanuel et al., 2007). This needs more research and development.

Finally, although these combinations of strategies are not sufficient to make a big change in thermal comfort, the developed scenarios show modest improvements. Modifying existing building regulations (FAR, plot coverage etc.) to accommodate these can improve thermal comfort.

4.3. In-depth discussions with Professional

4.3.1. Interviews:

This part of the research focuses on the current degree of implementation of these urban strategies and local planning level and getting insights on underlying problems of strategic implementation. In-depth discussions were held with six professionals who had thorough practical experience in dealing with planning agencies and influencing the planning landscape of Sri Lanka. The above results of the thermal comfort trend in Sri Lanka and thermal comfort simulations for an ideal neighbourhood regulated by CDP were used as aiding material in probing the participants for rich insights during the discussions.

Table 8: Key findings from the Interviews

Key interview findings						
	Questions	**AC1**	**AC2**	**PR1**	**PR2**	**DR1**
Colombo Planning Context	*Key focus of CDP*	-Zoning based development	-Transport -Housing	-Zoning plan based on Land-use development	-Land use plan -Transportation	-Compiled with NPPD -Social housing -Waste management
	Key challenges in Colombo	-Ad-hoc development -Colombo as real estate bubble -High traffic	-Urban flooding -Transportation issue -Underserved settlements-housing issues	-Haphazard development and urbanization -Urban flooding	-Bringing the investors -Poor infrastructure development - Uncertainty of regulation system -Lack of resources and labour -International competition	-Wetlands& marshes encroachment -High demand for development -Poor infrastructure facilities -Lack of funding & foreign debt -Urban poor- housing issues
	Efficiency of CDP	-Very abstract- no proper development guidelines -Zoning plan is not adequate	-Zoning plan is a good start but needs to be detailed.	-Our planning system is not efficient and does not address the current challenges	-Not efficient at all.it is not a wholistic approach	-Not efficient-an outdated plan
Urban Climate -Colombo, Sri Lanka	*Has overheating issue recognized as an issue in Colombo?*	-Reflected only in documents; no visible actions	-Slow realization and a sect of professionals have just started to voice out	-People are aware of urban heat. But before that we have many issues to be resolved.	-Climate change adaptation plans are just documents. No implementation.	-People do not care about urban warming if the priority is bread and butter
	Does the CDP address overheating issue	No	No	No	Not at all	No
	Should overheating issue addressed at policy level	-Yes definitely. But no actions are made.	-Yes, priority should be given- should be a key objective in planning	-Yes, we should address at policy level.	-Yes obviously, it should be national goal	-Of course, yes.
	knowledge gaps related to urban climate	-Studies are available. But no implementation	-Lack of research in our context. We need ground level studies to practically apply in our context. We cannot apply foreign knowledge to our context	Visible improvement in research quantity. But lack of guided research since not much experience on this field.	-We need a global platform to discuss these issues. There is no point in finding and researching in isolation.	- Climate knowledge is subjective at a given time

Climate-sensitive design	*Climate-sensitive design strategies in existing building regulations*	-Not incorporated in planning. -But initially was maintaining garden city.	-No mentioned in plans. -Low density allows wind flow. But not defined.	-Green and urban form somewhat regulated. -But no conscious effort	-Design strategies are not considered at all.	-Urban form & green indirectly regulated through FAR & plot coverage.
	How practical are these to incorporate in planning	-Need to comply with market forces- because investors try to build the maximum. They try to manipulate.	-Balance between environmental concern and financial aspects.	- Need to change the paradigm of how we look at regulations. Because current planning concepts are not efficient. Eg: building typologies	-It is practical. Need more effort	-Can incorporate. But governments priority is investors.
	climate-related checkpoints incorporate in the planning and designing process	-Again, it becomes a permit only and end up in documents	-It's a good start. But public should do this consciously.	-It is possible with construction audit. But need more resources	-Could be done. But before that we should have own parameters, modelling & simulations etc.	- Yes possible, we proposed town planner's assessment certificate.
	key challenges to making urban overheating in planning decision	-Political manipulation in environmental authorities -Professionals, politicians & public unaware of urban warming. -Vague guidelines -Corruption in the system	-No public awareness -Lack of relevant research -Inadequate data, resources, and technologies.	-No strong enforcement plans -Fragmented authorities -Limited knowledge on urban climate among professionals. -Lack of focused research	-Lack of political will -Weak policy framework -Authorities run individually -Lack of public awareness -Lack of resources & labour -High construction cost -Inadequate data	-Difficult to get politician's consent -Colombo has to develop on its own funding -Unavailability of resources -Lack of public awareness
Implementation - planning	*Effective measures*	-Public participation should be incorporated -Integration of authorities -Climate assessment as a requirement at doners funding agencies. -Initiate with public buildings - The government showcase examples -Renovate old building stocks responding to urban overheating.	- Actions to increase sense of urgency - Develop a proper communication system to emphasize the need of climate emergency - Climate forums- broader debate among professionals	- First identify the small interventions and make a flexible planning system to implement them. -Interventions must have tied up with financial incentives. - Need collaboration among climate research and urban designers -Consult climate experts for planning & development	-Incentivized planning system- investor-city council relationship -Develop cross-border relationship - Climate studies should be incorporated in the curriculum- educational system- schools, university -Integrating/ merging the relevant authorities for a wholistic approach	-Incorporate new tech. -Educate people. -Accommodate public participation -Learning lessons from other countries. -Climate studies in the educational system -Town planners assessment certificate prior to building projects -Need Climate sensitive strategies with social inclusions while convincing the politicians.

4.3.2. Thematic Analysis

The thematic coding results provide ‘meanings implied’ and insights on the nature of the current planning environment and the strategies to integrate climate sensitive planning. The themes and subthemes generated from the analysis is depicted below.

Name	Files	References
Insights - through research & data	5	23
Through Precedence	1	6
Through data	3	8
Through research	5	9
Continuity - Rome was not built in a day	4	24
Inception to Completion - Audit	3	5
Contnuity of policies despite regime changes	4	9
Periodical review	2	10
Commitment -act upon the word	4	30
Public commitment	2	2
Political Will	3	8
Commitments - Documents to Practice	4	10
Professional Ethics	2	10
Exortation - shout out, convince, urge	5	40
Incentivize	3	11
Awareness	5	29
Integration - policy, authority & expert opnion	5	59
Integration of administrative departments	3	7
Integrate expert opinion	2	7
Public Consultation in planning	3	8
Policy level interventions	5	37
Specify - God is in the details	5	68
Picking the low-hanging fruits	2	3
Vague guidelines - No focus	4	19
Macro to Micro	4	21
Strategic solutions	5	25

Figure 11: Themes and Subthemes

i) Insights – through research and data:

This theme was constructed with ideas revolving around gaining more information, research, and knowledge for an informed planning process in mitigating UW. The subthemes are direct references of sources that help in making an informed decision. During analysis, "Public consultation" and "Expert opinion" were also coded under this theme, which was later moved to – "Integration", as it is a participatory requirement during the planning process, whereas sub-themes coded under this theme can be developed in isolation to the planning process.

Name	Files	References
Insights - through research & data	5	23
Through data	3	8
Through Precedence	1	6
Through research	5	9

Figure 12: "Insights" & relevant sub-themes

a. Through research:

One of the questions in the interview was regarding the existing knowledge pool of urban warming mitigation studies in Sri Lanka and the knowledge gaps of the same in planning. The participants gave mixed answers in which two of them clearly identified that there is a lack of contextualized local research.

AC2 claims that there are no specific studies, "*there are very general studies, which we can't make any decisions*". The importance of context can never be undermined in climate studies and strategies (Rode, 2016).

Similarly, the quality of research is also important. PR1 identifies that although there are a few local UC related research, the quality of research seems to be less focused and ineffective when formulating ground-level solutions. He identifies the main reason being "*lack of guidance in research*".

AC1 brings another dimension to the research and knowledge pool, where he claims that sometimes quantitative research can be isolated, assumption-based and be obtained with erroneous or manipulated data, and thus, he stresses the need for more qualitative research to identify new insights.

DR1 was more concerned with the integrating knowledge and awareness into the school curriculum: *"if there is a strong program to incorporate knowledge in the education system, there will be a definite change in the next ten years".*

b. Through Precedence

Throughout the interview, there were references indicating the pros and cons of referring precedence from other countries. When discussing the new development plan proposed to the government, DR1 states that we can "*learn lessons from other cities*" without reinventing the wheel.

When discussing strategies to improve thermal comfort, PR2 claims that precedence can only be a starting point but cannot be implemented as it is.

"*We need to have our own system of determining these things – our comfort level is completely different for a person in Europe. Their comfort level may be cold for us. Thus, we need to contextualized modification of urban climate parameters, rather than borrowing it from the West*."

Conversely, PR1 claims that solutions based on other countries should be critically questioned prior to implementation in our context. He states that *"You can't compare Singapore and Hong Kong with Sri Lanka, their mindset is different, the focus is different… these are high density, well-developed cities. The Megapolis development plan is a failure as we have tried to imitate Singaporean designs".*

c. Through data

Organized data is knowledge. We can gain a lot of insights through data. However, there is no proper way of storing, categorizing and centralizing data for future use in the current context.

When speaking about strategies to identify and prioritize climate-sensitive planning, AC1 asserts the importance of having data recorded and available and a centralized place for future use. This could be past climate disasters, surveys, reports, any modelling, or simulations done etc. PR2 also stresses the importance of coordinated data and having previous models/ simulations available for the use of designers.

PR2 contends that the data sought by the Meteorological department stands in isolation and is not utilized by the UDA. Mills et al. (2010) also calls for integration of meteorological data in the planning system for useful UC actions.

ii) Integration – policy, authorities, and expert opinion

This theme was a result of ideas revolving around integrating a value addition to the existing planning process.

Name	Files	References
Integration - policy, authority & expert opnion	5	59
Integrate expert opinion	2	7
Integration of administrative departments	3	7
Policy level interventions	5	37
Public Consultation in planning	3	8

Figure 13: "Integration" & relevant sub-themes

a. Policy Integration - Bread and butter OR roof and shade?

While discussing the opportunity of prioritizing UW mitigation in the planning environment, a common idea was *"we need climate actions, but there are other priorities…." (AC2),* where the priorities are social and economic challenges. This theme was constructed initially as "Climate mitigation as a second-order planning decision".

"Unless we integrate social, financial and cultural benefits, implementation of climate mitigation strategies will tend to fail."– PR1.

Social housing, transport and waste management are some of the key challenges that have governed the planning landscape over the past decades (Ministry of Megapolis and Western Development Authority, 2016), and have been vouched for by the participants, during the open-ended interview.

AC1 states, "… *there is more than 50% of underserved settlement in Colombo. There has been a long-term agenda in addressing this, but still we have failed to find a successful solution…".* Echoing the same idea and adding depth to it, DR1 states, "…*Colombo is a wetland-based city – we need to plan based on the ecological strength of the city, these*

wetlands act as ecosystem services, but encroachment into wetlands and marshes has posed a serious threat."

Encroachment and urban sprawl are a serious problem in Colombo, which has not been addressed adequately over the past decades (Jayathilaka, 2017; Antalyn & Weerasinghe, 2020). DR1 states, *"Colombo being the primate city has attracted a lot of demand pressure over the years. Infrastructure development, transport, waste management have been unresolved issues for decades, and the high demand for development will only make it more challenging in addressing these."*

AC1 stresses that we need to cater for this demand. Commenting on the existing regulations as "restrictive in nature", he states that planning regulations must consider market forces and allow optimum built form, thereby encouraging developments.

The discussions also highlighted the crucial necessity to address climate disasters such as urban flooding, landslide, degrading air quality etc., through planning practices. AC2 acknowledges that UW mitigation should be a priority in planning but must be integrated with other policies. PR1 says that there should be a balance, as "*…ultimately it all boils down to the bread and butter of common man…"*. This has been instigated in Organization for Economic Co-operation and Development (2009) which states, there is a strong link between poverty alleviation and climate change adaptation.

Connelly et al. (2012) discusses the key concepts within sustainable development and recognize that social and economic practices are inseparable from sustainable development and needs to be integrated within those policies. This is also advocated by the New Urban Planning – Vancouver declaration (UN-Habitat, 2014). However, this leads to a debate whether climate mitigation strategies should be considered as a second-order strategy or rather a first-order strategy – neglecting climate risks have led to severe climate disasters in the recent past, and this can be avoided by evaluating climate risks and prioritizing them.

b. Policy Integration – Top-down / Bottom-up

When discussing whether UC can be governed, PR1, DR1 and AC2 state that it can be governed from a top-down approach since Sri Lanka is administered by an executive presidency, and it is relatively easy to impose regulations that will trickle down to ground level. PR2 further draws the fact that there is "no room for objection" of regulations like in countries like the UK and Australia.

AC1 and PR2 state that UC can be governed through a bottom-up approach. AC1 states that even though policies are imposed, they could be easily manipulated by the "middle management" i.e. regulatory agencies, which have the power of implementation. Due to corruption and malpractices, this might not be implemented effectively, or rather end up only in documents. However, if the public is aware of the adverse climate effects and there is a strong urge to uphold UC action within the people, the middle management will feel pressure from top and bottom.

DR1, AC1 and PR1 also insisted on the need of public participation in the planning process. PR1 says that the indigenous knowledge of traditional architecture was very much based on thermal comfort and the planning can gain insights from them. AC1 indicates the need to make involve public to dissipate knowledge and make them aware.

c. Integrate Expert Opinion:

Integration of professional inputs at the beginning of the planning process and tying them up throughout the implementation process was identified as positive reinforcement in UW mitigation strategies.

PR1's views were more of conservationist school of thought, where he claims high risers everywhere aren't a solution to Colombo's high demand of floor area and claims them to be a threat for UW. Another view is that DR1 argues that during modelling for the downtown of Colombo (Slave Island) with the help of experts, it was identified that high risers could actually improve the wind flow of a city. As attracting investments is a necessity for the economy, it would be beneficial to integrate expert opinion in shaping the building landscape to mitigate UW.

PR1 and DR1 indicate the instigation of a town planner assessment, which has all necessary checkpoints – climate, environmental, material, UW, waste management etc. This has been proposed by the UDA as a measure to integrate professional input in planning but has still not been implemented.

In contrary to policymakers approaching professionals, professional too have the responsibility to make an initiative in voicing out their opinions. This has been discussed under the theme "Exhortation".

With the growing importance of sustainable urban planning, policymakers and planners are responsible for identifying thermally vulnerable areas in the city and plan accordingly, which requires knowledge and expert input (Agathangelidis et al., 2019).

DR1, who has led a new development proposal in 2019, claims that his new proposal has utilized green areas along water bodies to mitigate urban warming" – although there are claims of sustainable developments, most of them are add-on/ plugins / which is often a makeover/ afterthought process.

d. Public Consultation.

Public consultation is a part of sustainable planning. AC1 claims that involving the public during the planning process will not only allow indigenous knowledge to integrate with planning, but also will act a form of educating the public with regards to UC mitigation. He also says that if the locals are informed regarding any developments in the neighbourhood and if we involve public during the planning process, there could be more control over the developments.

DR1 and AC2 both imply the need of regulating public consultation as a mandatory requirement in the planning system for effective climate strategies.

While studying "Inclusive approaches to urban climate adaptation planning and implementation in the Global South", Chu et al. (2016) finds that participatory approaches higher climate equity and justice outcomes in the short term, while integrating multi-sector organizations will lead to long term programme stability.

e. Integration of administrative Institutions

One common issue identified in implementing efficient mitigation strategies is fragmented institutions of planning authorities. This was openly discussed by 5 of 6 participants, thus led to a straightforward theme.

When inquired about existing climate awareness amongst the public and the government, PR1 says that there is a considerable knowledge base, but the issue is that there are several planning agencies with overlapping responsibilities – *"We have a DMA to deal with natural disasters, a CEA to deal with environmental protection, a UDA to deal with urban development, also NBRO, which is not a planning authority but dealing with landslide and*

other concerns etc. If you want to get a development permit, you are being sent all these places to get clearances."

PR2 indicates that the implementation of development plans is "*not even 50% efficient" and indicates fragmentation of institutions a key reason for this. The NPPD develops plans at the national level, but these are not backed by financial plans. They only work within their own scopes. Thus, the plans mostly end up in only documents"*. PR1 also indicates we have a separate Climate change secretariat, and environmental ministry are not synchronized in an effective way to provide solutions. Further, he indicates that this can lead to finding a loophole to get through this rather than consciously responding to the situation.

Institutional fragmentation is a key challenge in implementing coordinated decisions. World Bank (2020) identifies that various bodies manage the implementation and enforcement of planning, building, and fire regulations in a building regulatory framework assessment done for Sri Lanka. Consistent and coherent development plans are achieved through coordination of central agencies (Maddison & Denniss, 2009).

1865	**Colombo Municipal council**
1887	**Forest Department was started as the Office of the Conservator of Forests- British officials**
1921	City Plan by Sir Patrick Geddes. *City of Colombo: "The Garden City of the East".*
1940	Plan by Clifford Holiday *This emphasizes on controlling the people movement by "Zoning", which he assumed would regulate and stabilize the future growth of Colombo. Commercial, industrial, and residential areas were provisionally defined in this plan.*
1948	The Regional Plan by Patrick Abercrombie *The plan proposed to decentralize city functions into three new satellite towns of Colombo city such as Ratmalana, Ragama and Homagama.*
1951	**Department of Meteorology**
1966	**The Ceylon tourist board**
1968/1982	**Sri Lanka Land Development Corporation**
1978	**UDA established**
1978	UNDP Assisted Colombo Master Plan *The Regional Structure Plan and the Urban Area Development Plan*
1979	**National Housing development authority**
1981	**Coast Conservation Department (CCD)**
1981	**Central Environmental Authority (CEA)**
1984	**National Building Research Organization (NBRO)**
1985	City of Colombo Development plan- UDA+ UNDP team
1998	Colombo Metropolitan Regional Structure Plan *plan was influenced by the three pillars of sustainable development concept namely the Society, Economy, and the Environment.*
1999	**City of Colombo Development plan**- *As an amendment to the Colombo City Development Plan – 1985. It was prepared based on the Core Area Plan of CMRSP – 1998 hence, follows its planning guidance given for the City of Colombo.*
2001	**The Ministry of Environment**
2001	**National Physical Planning Department**
2004	Western Region Megapolis Plan. *Commonly known as "CESMA Plan" among Planners. The objective of preparation of this plan was to make Colombo a modern city that would play a key role in the South Asian Region*
2005	**Disaster management Centre (DMC)**
2008	City of Colombo Development Plan (Amendment)
2008	**Climate change secretariat Sri Lanka under ministry of Mahaweli development & environment**
2007	**Sri Lanka sustainable Energy Authority (SLSEA)**
2009	**Green Building council** *The aim of GBCSL is to transform the Sri Lankan construction industry with green building practices and to fully adopt sustainability as the means by which our environment thrives, economy prospers, and society grows to ensure the future wellbeing of our motherland.*
2012	National climate change policy by CCS
2016	National adaptation plan for climate change

Table 9: The Authorities and development plans formed over the years

The above table demonstrate the authorities and development plans formed over the years. The discussions reveal they are not integrated and do not focus on UC issues.

iii) Specify – "God is in the details"

This theme was the most referenced, with 61 references throughout the five interviews and was constructed with ideas revolving around "lack of detail" and "the need for conscious specified regulations" throughout the interview.

Name	Files	References
Specify - God is in the details	5	68
Vague guidelines - No focus	4	19
Strategic solutions	5	25
Picking the low-hanging fruits	2	3
Macro to Micro	4	21

Figure 14: "Specify" & relevant sub-themes

a. Vague guidelines – no focus

AC1, PR1 and PR2, all three have explicitly implied that the existing regulations are very vague and are not focussed. DR1 expresses that the existing plan is not fit for current development yet does not explicitly state that these are not detailed enough.

AC1 and PR2 implied that the development plans are not focussed for UC actions, PR2 further elaborates – *"…the existing development plan is not adequate to address climate issues, let alone other issues such as transport, waste management etc…", "… the CDP is very generic; and not specific, not focused; not even 50% is efficient. I would say that CDP is more a regulatory plan rather than a development plan…".*

DR1 and AC2 both indicate that the CDP, which was developed in 1999 and amended in 2008, is outdated and does not have provisions to address recent concepts related to global warming, sustainable development, social inclusions etc.

Local authorities and the UDA control most developments in Sri Lanka. The CDP is the ground level guidance for any development in Colombo and specifying this in detail will allow more control over the developments.

b. Macro to micro

The existing development plans are identified as a mere zoning approach, which must be detailed:

AC1 – *"The current plan is limited to only zoning and building heights, and since no specific guidelines, one can easily manipulate the regulations, especially investors and politicians"* PR1 and PR2 also acknowledge that existing zoning-based guidelines could be easily manipulated. DR1 states that zoning is a good initiative but must be detailed.

AC1, PR1 and PR2 discussed moving to the 'next level' of zoning – developing regulations for districts, neighbourhoods, streets etc. PR1 and AC1 say that we need to consider detailed design guides for clusters or neighbourhoods while developing regulations addressing UHI/ UW issues. He elaborates this saying,

> *"…our building regulations are single entity focused – the concerns are only the plot. Spaces in between the buildings are not covered. Wind flow within neighbourhoods, shading effect from adjacent buildings etc. are not considered…"* – PR1.

PR2 also stresses the need to consider smaller districts in planning while drawing examples of Singapore planning, where guidelines are based on smaller areas and will lead to more sensible plans.

Further, building typologies could be considered while developing regulations. In terms of implementing detailed design guides, PR1 indicates that we should change the paradigm of how we look at our building regulations.

> *"…our regulations are more land oriented – land-use base. If we r concern about these heat island and urban warming issues, we need to more focus on building typologies rather than land uses. All these strategies can be introduced if it comes with building typologies to suite the UC and localities. We need to address these issues at a policy level."*

The issue in these guidelines is that these guidelines are developed on a broad zonal basis of the city and thereafter focuses on a single building entity in terms of regulations, energy guidelines etc. Futcher et al., (2017) illustrates an example of the effects of regulating urban neighbourhoods, where a tall building casts shadows over a solar array or increasing the

heating loads to an area below, and further, clusters of tall buildings have the potential to provide mutual shading, lowering cooling loads.

c. Picking the low-hanging fruits:

Preparation of detailed guidelines will take time. Thus, PR2 and PR1 suggested the implementation of a hassle-free planning process for smaller developments. PR1 suggests that this can be detailed to encourage UW mitigation, such as retrofitting existing buildings to encourage shade, greenery etc., convert impermeable material to permeable/ thermally reflective materials etc.

Integration of climate checkpoints can also be attributed as immediate measures. Incorporating town planner's assessment and accepting it as a requirement by donor agencies was also suggested as an immediate measure in the planning process by AC1.

d. Design strategies:

This sub-theme was constructed as a summary of all design strategies discussed during the in-depth discussions. Firstly, the four design strategies to mitigate UW was discussed with the participants and inquired regarding the current degree of implementation of each as tabulated *below*.

	Urban form	***Vegetation***	***Wind flow***	***Albedo***
DR1	0 Somewhat through Plot coverage, FAR	+1 - 'Garden city' concept - Regulated through plot coverage	-1 No consideration	-1 No mention
PR1	0 Somewhat through Plot coverage, FAR No conscious effort	+1 "Colombo is still green", through plot coverage and reservations	-1 Planning guidelines are single entity focused. Wind is not considered.	-1 "No materials specifications at all"
PR2	-1 Plot cover, FAR does not imply positive climate action. We need to specify.	-1 Might/might not grow green in their premises. If the plot coverage is 65%, you cannot expect other 35% to be green.	-1 Sea front developments enjoy the wind flow. But it is not penetrated to the city. No mention in documents.	-1 No mention in documents
AC1	-1 development plan/ building regulations do not regulate the urban form climate responsiveness.	+1 maintain garden city character.	-1 Not considered n planning	-1 No mention in documents
AC2	-1 Possible unfavorable condition due to unregulated building height, streets, zone issues etc.	-1 Very first plan promoted green. Current plan does not mention about green.	0 Low densities allow more air circulation, sometimes indirectly help wind flow.	-1 No mention in documents

Table 10: Incorporation of design strategies in CDP

Secondly, all design strategies discussed were tabulated as regional, local, and building-level strategies and were compared with literature review and planning documents in Chapter 2.

	Design Strategies	Discussion	Literature	Planning Docs
Regional/ City Level	-Revisiting the notion of urbanization- developments of regional or satellite towns rather than concentrating in Colombo	x		
	-Considering cooling potential of river (Kelani river), canals around Colombo, large green areas when designing the street networks. Likewise, cities like Anuradhapura, Polonnaruwa could be designed considering large water bodies- lakes, reservoirs, and forest.	x		
	-Colombo is in the coastal belt. Streets and plots to be designed allowing the sea breeze and monsoonal wind.	x	x	
	-Develop a blue-green network in Colombo	x		
	-Transportation network could be designed in the periphery of the city centre, allowing limited number of vehicle fleet to the city while forming the ventilation corridors to penetrate wind. (this is beyond the research scope)	x	x	
	-Sea front developments with low heigh profiles and low density allowing the wind flow into the city.	x	x	
	-Special developments with high rises and multi storied complexes should designed with blue-green features while not hindering the neighbourhood developments.	x	x	
	-Buildings around the water bodies and open/green spaces (Galle face green, Beira Lake) could be designed low-rise allowing the air movement/cool breeze to the adjacent neighbourhood.	x	x	x
Local / street	-Area/street specific guidelines should be developed in detail. (Building height, street width, position of trees etc)	x		
	-Incorporate wind direction & patterns when developing zoning plans, designing street.		x	
	-Determining the plots size, and orientation at different zones-to maximize the air flow and green cover. Eg: longer frontage in parallel to wind direction while matching the market force.	x	x	
	-Promote green network within the streets-green corridors and tree lines along the pedestrian access and vehicular routes to enhance shading that will promote walkability.		x	
	-Provide green pockets at every neighbourhood	x	x	
	-Incorporate Green factor calculations in development projects.		x	
	-Placement & selection of trees (height, canopy size, type of trees & tree intervals) to provide shading, thermal comfort, and pollution filtering while minimal hindrance to wind flow. (Need more research on this area).	x	x	
	-Provide waterbodies at communal spaces for evaporative cooling.	x	x	

	-Determine the aspect ratio to increase shading by the building itself (some part of Colombo, Pettah, Slave Island realizing this aspect) at the same time not leading the air pollution.	x	x	
	-New streets could be designed NS orientation as they perform better than EW. However, existing streets cannot be changed. So shading devices could be designed for existing streets.	x	x	
	-Cool materials should be applied for urban paving rather avoiding concrete paving. Increase permeable areas – grass paving for parking and pedestrian walkways.	x		
	-Promote community level garden (urban farming) it accomplishes dual purposes.	x		
Micro level/ Building	-Creating a balance between site coverage, building plot and open spaces to maximize the green cover efficiently.	x		
	-Defining the building setback, rear spaces with vegetation cover	x		x
	-Provide site specific details (landscape details, green percentage, adjacent plots details) at planning clearances	x		
	-Building position and orientation to cut solar radiation and promote air flow around the building.		x	
	-Terraced podium/building form design to allow air flow. Design porous (gaps, openings) building.	x		
	-Provide arcades, awnings, and other shading devices at the ground level for pedestrian comfort.	x	x	
	-Introduce Energy performance certificate (EPC) for the buildings. Make this certification compulsory for new buildings and provide retrofitting solutions for old building stocks. Energy efficient buildings positively affect the outdoor. (In and out is linked and mutually affected)	x	x	
	-Introduce national building codes (NBC)– specify thermal reflective materials, colours, paints which enhance reflectivity.		x	
	-At commercial areas advertisement boards, sign boards to be placed not to block the wind flow.		x	
	-Educate people on outdoor working time. Avoid workers at afternoon hours where solar angle is high and continue at evening.	x		

Table 11: Design strategies - regional, local, micro level

Most of the above design strategies obtained from interviews were also reflected in literature. However, these weren't captured in the CDP, which is deemed to be a huge gap in the existing planning regime.

iv) Exhortation – Shout out, Convince, Urge

Exhortation means to strongly encourage/ urge someone to do something. Fenna (2004 as cited in Maddison & Denniss, 2009), describes this policy instrument that promotes voluntarism. UC action is a collective measure, and thus, will not be effective unless strong persuasion is involved – especially in a third world developing country where the primary concern of the majority is their "bread and butter".

Name	Files	References
Exortation - shout out, convince, urge	5	40
Incentivize	3	11
Awareness	5	29

Figure 15:"Exhortation" & relevant sub-themes

a. Creating Awareness:

All 5 participants during the conversation implied that awareness is a requirement for successful UC action. AC2 states that *"making people aware and convincing politicians"* is essential to practically incorporate UC checkpoints, if not, they might end up as mere checkpoints to gain a tick in the documents.

AC1 also reflects on the above idea, further stressing that communication strategies should be catered according to the target groups, i.e. public, professionals and investors accordingly, rather than mass communication strategies – "*We should explain the same thing for different groups with different methods, not only through different languages but the content also should vary"*. He also implies that it is the responsibility of the professionals to voice out their inputs and opinions in bringing a change to the system.

When discussing the possibility of a change in the planning system with a focus on UC actions, DR1 advocates the integration of climate awareness and heat-related health issues in the education systems:

> *"We can't bring change overnight. But we can educate the future generation. I strongly believe if there is a programme to integrate this to our education system, we can make a big change in 5-10 years".*

A mode of creating awareness is also by setting example – i.e. a model building that adheres climate-sensitive strategies to can be led by government, which was indicated by PR1.

b. Incentivized planning:

PR1 stresses at several instances during the conversation that climate-sensitive design approaches should be tied up with benefits – specifically financial benefits – to encourage people. These could be incentives, subsidies, loans, tax concessions etc. He also addresses the lack of motivation in implementing other good practices in the current development plan. PR2 also stresses the importance of the above, "*investors and the public can*

contribute a lot by tying up financial benefits in planning – a developer can give something to the city and take it back in return".

Owing to the vague guidelines in the CDP, investors can easily find loopholes, and this has led to a common practice of challenging the existing guidelines (as per ideas from AC1, DR1 etc.) to gain more buildable areas. Regulating these and offering incentives encourage more people and provide strong guidance.

v) Commitment – Act upon the word

This theme was constructed through indications of lack of commitment towards a goal and profession, which pose a threat in pursuing sustainable UC actions.

Name	Files	References
Commitment -act upon the word	4	30
Commitments - Documents to Practice	4	10
Political Will	3	8
Professional Ethics	2	10
Public commitment	2	2

Figure 16:"Commitment"& sub-themes

a. Commitments – Documents to practice

We are a part of international commitments, such as the Kyoto Protocol, UNFCCC- 4th conference etc. AC1 indicates that no effort is a mode to meet these commitments – "*we have nice set of documents, but nothing visible in practice".*

Further, PR2 and AC2 also indicate that checkpoints and assessments have a tendency to be existent only in documents and not in practice. PR2 says that - *"… the existing green building council rating focuses only on a rating system which has a minimum requirement, and once achieved, performance is not checked at the end…".*

While it is the responsibility of relevant authorities to ensure the commitments are met, PR 2 advocates that it is also responsible for policymakers to consider global fairness prior to undertaking such commitments, considering the country's economic and social conditions.

b. Professional/ public / Political will

A layman's first point of contact in expert opinion is the professionals – planners, architects, designers etc. Advocating for an effective bottom-up approach for UC governance, AC1 states that *"... if planners and architects consider their job at a more responsible and ethical angle, definitely these strategies be incorporated..."* He also states that professionals have the ultimate responsibility in advocating UC action to the general public, investors and politicians.

"Similarly, the public should also act responsibly", says PR2. Further he states that *"when there was a fine imposed for throwing thrash in the roads, the public obeyed; and once the implementation was stopped, they went back their old habits",* providing an insight of the public mentality that needs to be considered in making policies.

All participants strongly suggest a political will is an important factor for successful UC action. PR2 stresses that it is again the professionals' responsibility to convey the benefits in terms of financial benefits, and advocate benefits of UC actions.

vi) Continuity – "Rome was not built in a day"

The theme "Continuity" indulges with the notion of *continuous improvement* and *review* (consistency between planning bodies/ documents etc. will be discussed under the theme *Integration*) of planning, policy, audit and data in urban planning and governance.

Name	Files	References
Continuity - Rome was not built in a day	4	24
Contnuity of policies despite regime changes	4	9
Inception to Completion - Audit	3	5
Periodical review	2	10

Figure 17:"Continuity" & relevant sub-themes

a. Periodical review – planning:

The subordinate theme, "Periodical review - planning", implies that development plans should be reviewed once in a while. DR1 had repeated the idea that *"we have an outdated plan" and "we need a development plan that fits our context"* a couple of times throughout the interview. As a planner and an academic, he also insisted that the plans have to be

reviewed every 5 – 10 years and adopted accordingly to the context; instead, the current development plans and regulations still caters to the "last decade".

Both PR1 and PR2 had similar concerns in adopting a development plan that caters for the "actual trend". PR1, AD1 and AC1 imply that the land use method used in the current system has to be relooked – this will be discussed under the theme 'Detail'.

b. Continuity of Policies despite regime changes

This subordinate theme was constructed through explicit notions that political interference had influenced on genuine planning attempts. AC1 noted that *"There are government agencies such as Climate change secretariat, sustainable development authority etc. to maintain climate commitments and actions. But these are discontinued with government changes and regime changes."*

PR1, PR2 and AC1 also implied that all genuine efforts of planners and policy makers go astray due to political interference due to regime changes.

c. Audit – Inception to completion and during use

This subordinate theme was constructed as a result of ideas revolving around the notion of continuous monitoring of events in planning from inception to completion.

AC1 – *"We can add climate checkpoints to enforce climate sensitive planning, but this again becomes only a permit - will end up only in documents and not in practice. That's why I say that there has to be an independent assessment, even during construction".*

PR1 – *"There has to be a continuous audit system which monitors the construction from planning to completion. We can learn from countries like Australia, where for example, 5 of 8 parameters needs to be fulfilled for final approval".*

Three participants discuss the need for continuous monitoring for climate-sensitive planning. PR1 also indicated that the planning bodies lack of resources for undertaking a successful audit.

Monitoring, Evaluation and Reporting (MER) is a process that has been stressed for fruitful outcomes of policy, plan, or project. Murieta et al., (2021) and has been proved as an essential practice to ensure that the project objectives while enabling flexibility (Klostermann, et al., 2018).

4.4. Summary of In-depth Discussions

This section presents the summary of thematic findings, barriers, and opportunities

4.4.1. Summary of Themetic findings

The above emergent themes were occurred in the following hierarchy:

Name	Files	References
Specify - God is in the details	5	68
Integration - policy, authority & expert opnion	5	59
Exortation - shout out, convince, urge	5	40
Commitment -act upon the word	4	30
Continuity - Rome was not built in a day	4	24
Insights - through research & data	5	23

Figure 18: Identified Themes

- **Specify**: The CDP is outdated (20 years) and too vague (limited to zoning and land use) to be represented as a ground level regulatory planning guide for Colombo. Neighbourhood level, regional level planning and specifying regulations in detail is identified as a key strategy. A repeated notion is that *"if it is not in the documents, we can't expect it to be in action"*, which also gives an insight to the social values towards policy.
- **Integration:** There are many institutions that investigate various sectors of planning in Sri Lanka. Fragmentation of these authorities is one of the key issues in effective urban governance. Since social and economic polices draw a lot of attention, identifying suitable approaches for climate policy and integrating them with social and economic concerns will be effective. Further, incorporation of research, climate knowledge, expert opinion and public participation into planning has also contributed to the emergence of this theme.
- **Exhortation:** Climate concerns are not the primary issue of the public in a developing country. Thus, there is a need to create awareness and insist the public and politicians regarding the need for climate actions. This can be through mass media, debates, incentives and other means of promoting UC actions.
- **Commitment**: The policy drafts addressed to international organizations, should not only be action plan but also there should be ground level commitment. Further,

professional's ethical role in committing to their oaths is one of the emergent ideas under this theme.

- **Insights:** Gaining insights can shape the planning process for unique interventions. Apart from local guided research and precedence, the themes also suggest the importance of data – storing, categorizing, and making them available for inter-department/ future use – is one thing that will guide the UC action landscape of Colombo effectively.
- **Continuity:** Although it resulted with the least number of occurrences, this theme is vital for the policies are influenced by the changes in political landscape. The theme also suggests periodical review of the development plan and periodical audit of execution for a robust implementation.

While reviewing the themes, a cyclical process of actions was identified.

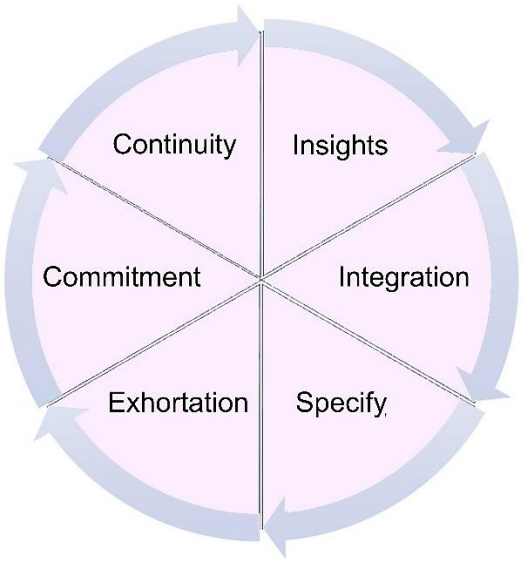


Figure 19: Cyclical process of themes

The above cyclical process can be developed further as a conceptual framework that promotes a spiralling effect of actions, with refined results at each end of cycle.

4.4.2. Word Frequency

Running a querry for the 250 most occurred words, combining the scripts of all 5 interviews, in NVIVO resulted on the following diagram:

Figure 20: Word Art generated through NVivo

The above emphasizes the need for “awareness” and “detailed plans”, and further reinforces the idea of social and political influences in urban climate actions.

4.4.3. Summary of Barriers:

Throughout the interviews, there were several instances of barriers were identified with regards to implementing an effective solution for urban climate strategies. These were categorized as political, social and economic and other barriers in *Table 12*

Identified Barriers
Political barriers
"Planning is essentially a political process" (DR1) -Lack of political will to incorporate urban climate in development plan. Politicians are unaware of urban warming and climate issues and their priority is investment related. Main challenge is how to take politicians' consent to implement the interventions. *(DR1), (PR2)* -Planning authorities as political puppets- Political manipulation in environmental authorities and climate activists. *(AC1)*
Economic barriers
"Colombo has to develop on its own funding". *(DR1), (AC1)* -Lack of government funds for climate related projects. *(PR2)* -No funding plans for climate change projects even in National physical development plan. *(PR2)* -Difficulty in bring in the investors for climate related projects. (International competition in attracting the investors). *(PR2), (PR2)* -Due to economic issues very less priority for environmental concerns. *(PR1), (PR2)* -Urban poor/ underserved communities -no attention for urban warming. If the peoples' concern is bread and butter, they will not worry about temperature rise". *(DR1)* -High construction cost. *(PR2)*
Social barriers
-Lack of public awareness: *(AC1), (AC2), (DR1), (PR1), (PR2)* professionals, politicians, and communities are unaware of urban warming. -Colombo as a real estate bubble- very high demand for development lead to urban warming and UHI effect. *(AC1)* -Ad-hoc (unplanned) development resulting urban warming. *"More than half of Colombo developments are illegal". (PR1)* -Corruption in the system. *(PR2), (DR1)* -Reluctant to change from the traditional building construction- long lifespan of building does not allow to change/ retrofit for climate. *(AC1)*
Other barriers
Policy-related barriers: -Colombo does not have specific legislation or policy guidelines to address the negative effects of climate change/ urban warming issues. *(PR1), (PR2), (DR1)* -Development guidelines are vague & zoning plans are primitive and are not focused (inefficient). *(AC1), (PR2)* -Loopholes in policy tend to be manipulated. *(AC1), (PR1)* -No strong enforcement plans. *(PR1), (PR2), (AC2)* -Planning permits & climate checkpoint tendency to fail due to corruption and bribing. *(DR1), (PR2)* -Green building rating system in Sri Lanka is not efficient and based on a business angle. *(PR2)* -Stagnated policy or rules- authorities are not updated. *(PR2), (AC1)*

Resource related barriers: -Limited knowledge on urban climate among professionals and local authorities. *(AC2), (PR1), (PR2)* -Lack of guided climate research focus. *(AC2), (PR1), (PR2)* -Lack of planning data for public access. Data is not utilized in optimum way. Guardian information it become null and void. *(PR2)* Eg: met data or resources from the UDA are not used. -Inadequate technologies and computer facilities. (Software and hardware) *(DR1), (PR2)* **Organizational:** -Fragmented authorities- there are many different and separate authorities but run individually and they are not synchronized. *(AC1), (AC2), (PR1), (PR2)* -In some authorities do not have the right people at right positions. *(PR2), (DR1)* -Under-staff at institutions. *(PR1), (PR2), (DR1)*

Table 12: Identified Barriers

The above identified barriers for planning context in Colombo could be categorized based on the framework developed by Ryan (2015) as shown in the *Figure 21*.

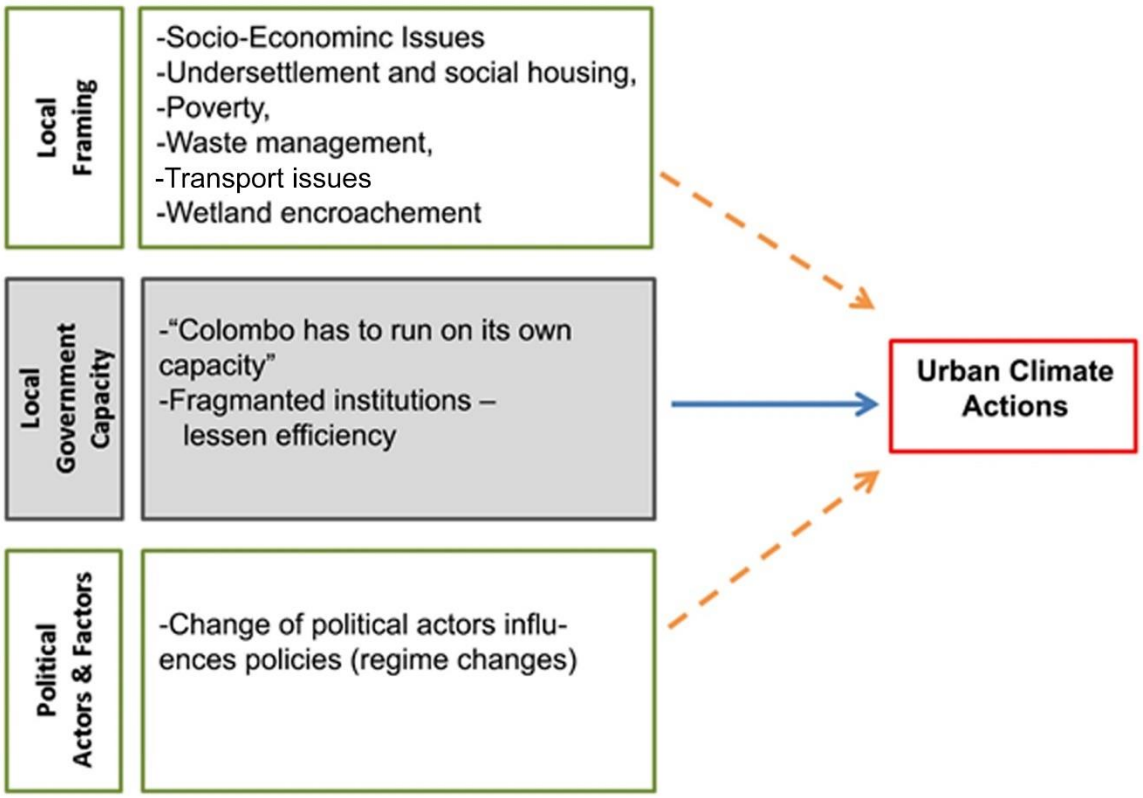


Figure 21: Categorization of Barriers according to the framework developed by Ryan (2015)

4.4.4. Summary of Opportunities:

The opportunities identified through the discussions are categorized according to the identified themes and is presented in *Table 13*: Identified opportunities during interview classified into themes.

	Identified Opportunities
Insights	-Consult climate experts for planning & development. (PR2) -Knowledge informed by research data, mapping, modelling, and simulations etc. should be incorporated in planning and design decisions. (AC2) (PR2) -Develop cross-border relationship to learn lessons from other countries. (DR1) (PR2) -Meteorological data to be facilitated to the authorities and designers. (PR2)
Specify	-Need a very detailed plan, for each specific areas/neighborhood (area specific details). (PR1) (PR2) (AC1) (AC2) (DR1) -Town planners assessment certificate (including climate sensitive assessment) prior to building projects. (DR1) -Implementations: First identify the small interventions and make a flexible planning system to implement them. (PR1) -Renovate old building stocks responding to urban overheating. (DR1) -Introduce Energy performance certificate (EPC) for the buildings. Making this compulsory for new government buildings and furnish with retrofitting solutions for old buildings. And gradually introduce for other private building stocks (PR1)
Integrate	-Urban climate related policies integrated with other socio-economic and environmental policies and developments (AC1) (PR1) (PR2) (DR1) -Climate sensitive plan should be embedded in National Physical Plan and that needs to be complied with finance plan. (PR1) (PR2) -Public participation should be incorporated as to understand the community aspirations. (DR1) (AC2) -Relevant authorities should be integrated and involved planning designing and decision-making process (UDA, CEA, Green building council, climate secretariate with finance departments). (PR1) (PR2) (DR1) -Meteorology department should be linked with policy makers and other authorities including universities, because now met data is in isolation. (PR2) -Lean governance of data in planning. (AC1) (PR2) -Need collaboration among climate research and urban designers. (PR2) -Climate studies should be incorporated in the curriculum- educational system- schools, university. (DR1) (PR1) (PR2)

Exhort	-Develop awareness: a way of knowledge transfer for different group by different practices: 1. General public, 2. Investors, 3. Designers/ architects/ Planner - Actions to increase sense of urgency on urban climate - Develop a proper communication system, video advertisements, lectures by the experts, climate forums- broader debate among professionals on urban warming issues, media campaigns etc. (AC2) (DR1) -Politicians and urban planners and designers can acquire the basic knowledge about urban climate through training activities. (AC2) - Incentivized planning system - Climate sensitive interventions must have tied up with benefits/ financial incentives. (Giving incentives, subsidies, loans). (PR1) (PR2) -Environmental concerns and solutions should be presented to attract the investors, politicians, and other stake holders. (PR2) -Strengthen the enforcement. (PR1) -Initiate with public buildings - The government could demonstrate and showcase examples of climate sensitive buildings. (AC1) -Need Climate sensitive strategies with social inclusions while convincing the politicians. (DR1) -Designing low-cost building for short lifespan to combat climate change- (Sri Lanka buildings last for many hundred years-need to change this phenomenon with urban regeneration. (AC1)
Commitment	-Climate assessment as a requirement at doners funding agencies- banks, finance agencies etc. (AC1) -Introduce climate checkpoints system in design and construction (AC1) -Committed to Green building rating system (PR1) (DR1) - Advocating for an effective bottom-up approach for UC governance (AC1)
Continuity	-Periodical review and update the plans every 10 years at least. (5 years recommended) (DR1) -Make plans to be continued despite the political regime change. (DR1) - Monitoring, Evaluation and Reporting (MER) of the plan. (PR1) (DR1)

Table 13: Identified opportunities during interview classified into themes

5. Conclusion & Recommendations

The study hypothesized that despite an imminent overheating threat, and despite recommendations of scholars to incorporate UC mitigative actions in planning, the building regulations of Colombo didn't seem to capture these in the ground level. Thus, the study aimed to resolve the following research question through a pragmatic approach:

> **"How is the importance of Urban climate actions perceived in the local planning context of Colombo and how can this be incorporated effectively?"**

The overall study relies on the findings obtained through analysis of the views of experienced professionals and academics as evidence (data), probing them with additional aiding materials to obtain enriched data. The perceptions of the importance of UC actions in Colombo is identified through the review of building regulations and interviews.

The results indicate the objective reality of overheating and indicate that this threat has begun to ignite debates amongst planners and professionals, yet no policy efforts have been synthesized. The key recommendations include locally guided research and awareness, exhorting the need amongst decision makers and the general public and making a continuous effort and progress.

5.1. Summary of Findings

- The overheating was quantified, and a significant trend shifting from strong heat stress to extreme heat stress was identified throughout the year in the whole island, except the hillside. In general, the hottest month is getting hotter, and even the coolest months depicts a reducing number of cooler days. In the past decade, Colombo has shifted from moderate stress to very strong heat stress and shows a positive trend towards extreme heat stress in the near future.
- The CDP was analysed whether the above strategies have been incorporated based on the author's professional experience, which was later cross-checked with the interviews. The initial review suggested the possibilities of integrating UC design strategies, but not with conscious intent and is tabulated in Chapter 2. However, this was challenged during the interviews as no specific mention or enforcement measures for thermal reflective materials, green cover, shading measures etc. Thus,

through the review and interviews it could be concluded that there are no actions to mitigate UW in the local planning context of Sri Lanka. A set of new building regulations was gazetted on 08.07.2021, at the end of the study period. An initial review indicated that these had not captured any conscious effort in enacting UC actions too. A requirement of green building certificate for public buildings and buildings with a footprint above 1000 sqm can be found, yet this has not captured climate checkpoints but rather limited itself to sustainability checkpoints.

- Simulations for a typical street in Colombo indicate that although strategies are not sufficient to make a big change in thermal comfort, the developed scenarios show modest improvements. Modifying existing building regulations (FAR, plot coverage etc.) to accommodate these can improve thermal comfort.
- The implementations strategies and challenges/barriers in incorporating Urban Climate actions in Colombo has been identified through the interviews and is tabulated at the end of thematic analysis in Chapter 4. Apart from the socio-economical barriers, political interference was identified as a key challenge for proper implementation of UC actions, which is a threat unlike 'lack of political will' as identified by Emmanuel (2009) and Mahanama et al. (2014).
- Lack of detailed development plans, fragmented institutions, lack of policy-level initiatives and political interference in the genuine planning efforts and changes in regime impacting planning were identified as some of the main weaknesses of the existing planning domain in incorporating climate initiatives.
- Semi-structured in-depth discussions revealed six themes that complement the integration of UC actions in the context of Colombo. A pattern was identified among the themes which can be developed as a conceptual framework for the effective implementation of UC actions.

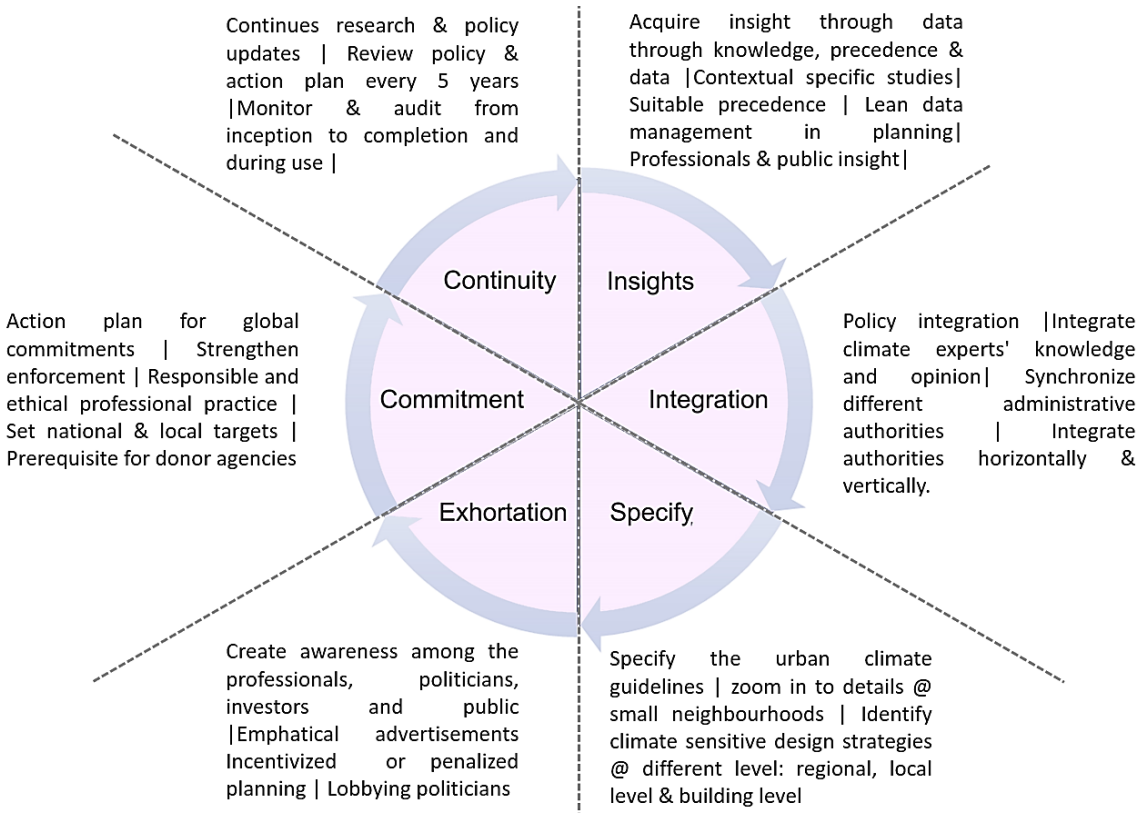


Figure 22. Identified Themes & Effective measures of practical course of actions

The above course of actions can create a spiralling effect (*Figure 23*) which can improve the integration of UC actions with time. This can be further developed as a conceptual framework.

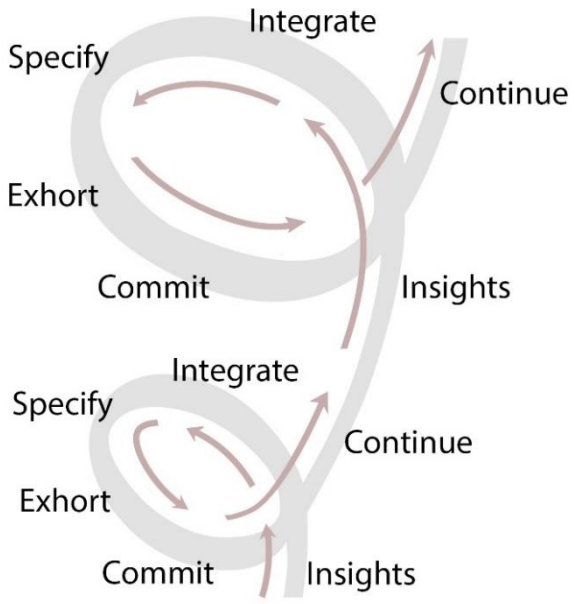


Figure 23: Proposed conceptual spiralling effect for implementation of UC actions

5.2. Recommendations:

- Urban warming in Sri Lanka is not recognized as an issue and is not considered in the urban planning decisions and processes. Urban climate mapping and modelling should be developed at a detailed level considering the neighbourhood level/ area-specific level when considering policy implementation.
- The climate change secretariate which was established in 2008 has only addressed issues related to climate disasters such as flooding, landslide, CO2 emissions etc. There is no mention of UC actions have been considered in their action plan. This has to be identified and incorporated as a key issue. (Section 4.3. - ii - e)
- The study identifies a challenge in policy integration. The interviewed policy-making professionals feel that tackling social and economic issues should be the key priority rather than urban climate concerns (Chapter 4). As a short-medium term initiative, the study thus suggests further research on the effectiveness of integrating climate policies within social and economic policies to cater Colombo's socio-economic, political landscape. However, attempts should also be made to exhort urban climate policy integration as a first-order policy initiative in the long run, since effective climate actions will always be socially and economically beneficial for a developing country in the long by eliminating cooling costs and promoting a healthy society.
- Another significant drawback identified was that the regulations are mainly single entity focused in Colombo, Sri Lanka. Space between buildings and the impact of neighbourhood developments are not assessed through regulations. Guidelines and building regulations should be designed to assess the spaces in between too. (Streetwise or neighbourhood wise) *(Under the theme "Specify")*
- The conceptual framework identified suggests actions similar to that of the cyclic process of action research process. This can be further developed and applied to in the planning context of Colombo. *(Summary of themes)*
- The study process portrays as an example of a practical approach towards incorporating UC actions in planning. The administration and academia can focus on pragmatic research and action research with multiple methods in focusing effective implementation of Urban climate actions. This also complements the question by (Lu et al., 2020) regarding an imperative of action research for the reduction of overheating in Sri Lanka.

5.3. The actors- who should be involved?

Urban warming is an issue that cannot be viewed in isolation but needs a holistic approach. Apart from the efforts of the epistemic community, a practical approach requires integrating all socio-political actors and institutions. The need of proper network amongst stakeholders related to planning, infrastructure and building construction were emphasized during interviews and is well-evident in themes Specify, Integration and Exhortation.

The actors and institutions connected with these three nodes (planning, infrastructure and building construction) concerning Colombo identified are described in *Figure 24.*

Figure 24. Mind map: integration and collaboration of different actors and strategies

5.4. Limitations:

- This study critically investigates the building guidelines, specifically on microclimate. Therefore, research is limited to the urban canopy layer with respect to the building regulations. The main idea being the building regulations/ CDP is the ground level implementation plan and all policies should be synthesized into this for effective implementation.
- Design strategies were identified to mitigate overheating issue, but not studies in detail. (Eg: how the individual and combination of strategies performs)
- This study only focused on design strategies in mitigating overheating and reducing overheating by minimizing anthropogenic activities (energy sector, transportation) were not considered.
- This dissertation focuses on the building sector. Health issues related to overheating is not studied. This should be further study-public attention on the health sector is high.
- These findings are subject to change with the ever-evolving nature of cities. Thus, there must be a continual research process and mending the above findings for the relevant temporal dimension.

5.5. Future Research

- Thermal maps were done considering Sri Lanka as a whole to identify the warming trends. Additional research at regional and city levels could be undertaken. Detailed mapping and modelling are required when developing design guidelines for specific areas.
- Detailed heatwave studies, considering daily data, can be identified heatwave prolonged periods.
- The spiralling effect which has emerged from themes can be further developed to a framework for implementation. Based on that, planning, and building guidelines could be modified.
- Lack of literature on political aspect on urban climate action is identified in Sri Lankan context which needs more research.

- The study limits to Colombo. However, with the development trend in Sri Lanka, other cities will also require individual research. The versatile nature of this pragmatic research can be adapted to other cities in Sri Lanka.

Urban overheating is an imminent threat in Sri Lanka that can have severe health consequences and further add unnecessary burden on the economy. Urban climate design strategies can result in an improved microclimate, yet a broader approach is required for considerable improvement in the urban climate. This can be done through incorporating it with socio-economic concerns (such as under settlement, poverty alleviation, urban regeneration, etc.) and integrating socio-political actors (planners, professionals, politicians, general public etc.). 'How' to do this needs more intense scrutiny, which merges context-specific scientific and sociological debates. One such example is that it can be supported by multidisciplinary research focus on urban climate, facilitating monitoring climate change in urban context and actively experimenting and developing new planning solutions considering local climate in different perspectives.

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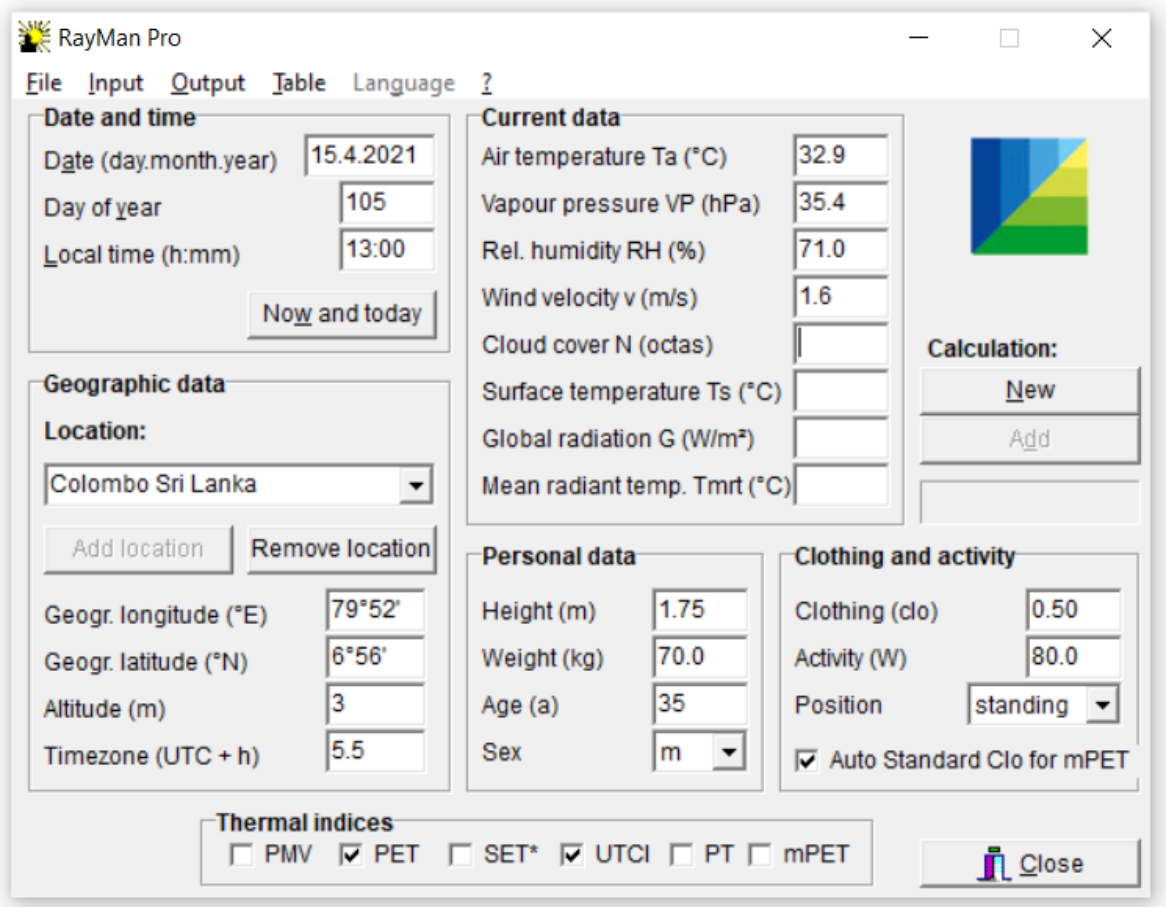
Appendices

Appendix 01

Input data for RayMan simulations.



Appendix 02

Developed Questionnaire for the Discussion.

Structure of the Discussion Questions

Introduction

With the end of the three-decade civil war in Sri Lanka and increased opportunities for businesses, Colombo has attracted numerous development projects. This has increased urban migration, and Colombo's population is ever-growing. The role of urban planning is more critical than ever.

Section 1 – Colombo Planning Context

The modern Colombo plan is based on the plan drawn by Sir Patrick Geddes in 1921. Over the course of time, many intellectuals, planners, architects, organizations, and authorities have developed various plans and development guidelines for Colombo. However, globalization and the demand for rapid development have constantly challenged these guidelines. These lead to constant alterations and re-interpretations of development guidelines.

1. The existing Colombo Development plan (2008 amended version) is a developed version of the 1999 Colombo Development Plan. What do you think, in practice, has become the key focus of this plan?
2. Can you elaborate some of the key challenges in Colombo's development plans?
3. Do you think that the 2008 amended version of the CDP address these issues efficiently?

Section 2 – Climate Change in Sri Lanka

Climate change is a significant issue throughout the globe. Urban Planners in other cities have explored the importance of climate-sensitive planning as a tool to combat global warming. In addition, urban warming and overheating issues have become hot topics in tropical cities, and these have become significant issues over a couple of years in Colombo.

1. How are climate change risks identified/prioritised in Sri Lanka?
2. In addition to more widespread climate issues in Sri Lanka such as urban flooding and landslides, how do you think the overheating issue/ urban warming, in particular has affected the lives of people? Do you think this is important, and should be addressed at the policy level?
    a. If YES – why? how?
    b. If up to a certain extent- How far?
    c. If NO – why do you think this is not important?
3. Does the Colombo Development Plan or any enforceable policy document has addressed these issues in particular?
    a. If YES – can you give any examples? Do you think this can be improved etc.?
    b. If up to a certain extent – Can you give examples? How can this be improved?
    c. If no – How can this be developed?

4. There are increasing number of studies (including our own) undertaken in urban climate mitigation in the tropics.
   What are the knowledge gaps related to climate sensitive design in Sri Lanka? (Regarding weather data, UHI issue, heatwave/ air temperature rise, GHG emission, building energy). Is this adequate? *(The thermal comfort trend maps done are shown to the participants at this point)*
   a. If NO – what do, we need?
   b. If YES – Have these been considered /incorporated in planning/ policy documents?
      i. NO- Why is it not incorporated? (Negligence, unaware?)

Section 3 – Climate-sensitive design - in-depth discussions on strategies

1. The following are a few design strategies that could mitigate urban warming in the microclimate: Urban form- H/W ratio, vegetation, Albedo, Wind flow – *(explain the design strategies and show RayMan simulation findings to participant)*
   a. Have these design strategies incorporated in existing building regulation? *(Discuss CDP based on strategies)*
   b. How practical are these to incorporate in planning building regulations? If applicable, where are the opportunities to plugin these into the existing planning documents?
   c. What are the main planning challenges/ barriers for integrating climate knowledge in planning practice?
2. In tropical cities like Singapore, and Hong Kong, urban developers are required to undertake air quality assessment, ventilation assessment, flooding assessment etc., for initial planning as well as subsequent building design approvals. In Sri Lanka, pre-planning assessments are limited to Traffic assessment, fire safety assessment etc.
   a. Could we possibly add another layer of climate-sensitive study, which might incorporate the requirement of massing, form, solid void study, material study, through simulations etc.?
   b. Where are the opportunities to incorporate climate study at building planning process- PPC level?
   c. Could climate-related checkpoints incorporate in the planning and designing process? If so, how can we do it practically?

Section 4 – Implementation of design interventions in urban planning

1. What are the key challenges to making overheating/ urban warming concerns an integral part of urban planning decision?

   a. If no implementation – WHY? - is it because no resources? Lack of knowledge?

2. Changes in the planning system

   a. What governs/influence the planning system of Sri Lanka most?
   b. Who are the stakeholders who can bring a change to the existing system? And what is the role of local authorities? Or What are the authorities should work together as a whole to make it happen?
   c. What are the effective measures that we can undertake to bring in the change required?
   d. How can be urban climate management process governed?

Appendix 03

Thematic Coding-NVivo

Name	Files	References
Specify - God is in the details	5	68
Strategic solutions	5	25
Public participation	2	4
Manipulation of urban form to enhance wind flow	2	4
Climate Mitigation Strategies	2	3
Building typologies vs Land use model	1	2
Promote development plans specific for rural and town areas	1	2
Low rise - context based strategies	1	1
Introduce green areas along water bodies	1	1
Consider built form and materials in planning	1	1
Regulate Urban Densities	1	1
Urban coding	1	1
Incorporate modern techonolgies in planning process	1	1
Project size based planning approval strategies (Nodes)	1	1
Rain water harvesting and rooftop gardening	1	1
Utilizing existing green infrastructure in tackling urban warming	1	1
Modelling and simulations - modern techniques towards detailed planning	1	1
Macro to Micro	4	21
Neighbourhood level planning	3	7
Develop area specific guidelines (at neighbourhood level)	2	5
Plan for smaller zones - subdivisions	1	1
Connected planning - regions, neighbourhoods, and plots	1	1
Regionalized planning	2	7
Approach towards Regional Developments	1	3
Development and facilities should be distributed	1	2
Relocation of industries - exisitng actions under way	1	1
Improvement of transport network for satellite developments	1	1
Contextual planning	2	3
Climate compliance checkpoints by regulatory bodies	2	2
EIA Assesments	1	1
Macro to micro strategies essential to tackle climate issues	1	1
Macro level	1	1
Vague guidelines - No focus	4	19
Design guides to be considered on top of zoning	3	9
Not at all efficient	2	4
Detailing of comprehensive development plans	2	3

Name	Files	References
Vague guidelines - No focus	4	19
Design guides to be considered on top of zoning	3	9
Not at all efficient	2	4
Detailing of comprehensive development plans	2	3
Manipulation of guidelines	1	2
Detailed plans leads to concrete solutions	1	1
Picking the low-hanging fruits	2	3
A prerequisite for donor agencies	1	1
Flexible solutions for minor alterations	1	1
Integration - policy, authority & expert opnion	5	59
Policy level interventions	5	37
Supportive policy integration	5	16
Proactive approach rather than a reactive approach	2	5
Climate checkpoints - acts only as another permit that could be misused	2	3
Climate impact assessment - a strategy for climate incorporation	1	2
Policy making from policy level	1	1
Policy level interventions - only practical way to solve	1	1
Implement policy level interventions and subsequent strategies	1	1
Democratizing planning - policy level intervention	1	1
Climate planning as a primary policy	1	1
Policy induces regulations	1	1
A bottom up approach	1	1
Public Consultation in planning	3	8
A more public freindly approach	1	2
Transparency - inform public regarding development inception to implementation	2	2
Involvement of public consultation from the very beginning	1	1
Strengthen legal framework in involvement of public consutlation	1	1
Improve broader debates, activities, mainstream discussions etc. in promoting awareness	1	1
Integration of administrative departments	3	7
Bridge gap between knowledge and practice	1	2
Integrate expert opinion	2	7
Professional voice in the planning process	1	3
Preliminary clearance to be obtained with a qualified professional's input	1	2
Optimize high development potential with expert opinion	1	1
Incorporate professional input in planning decisions	1	1
Exortation - shout out, convince, urge	5	40

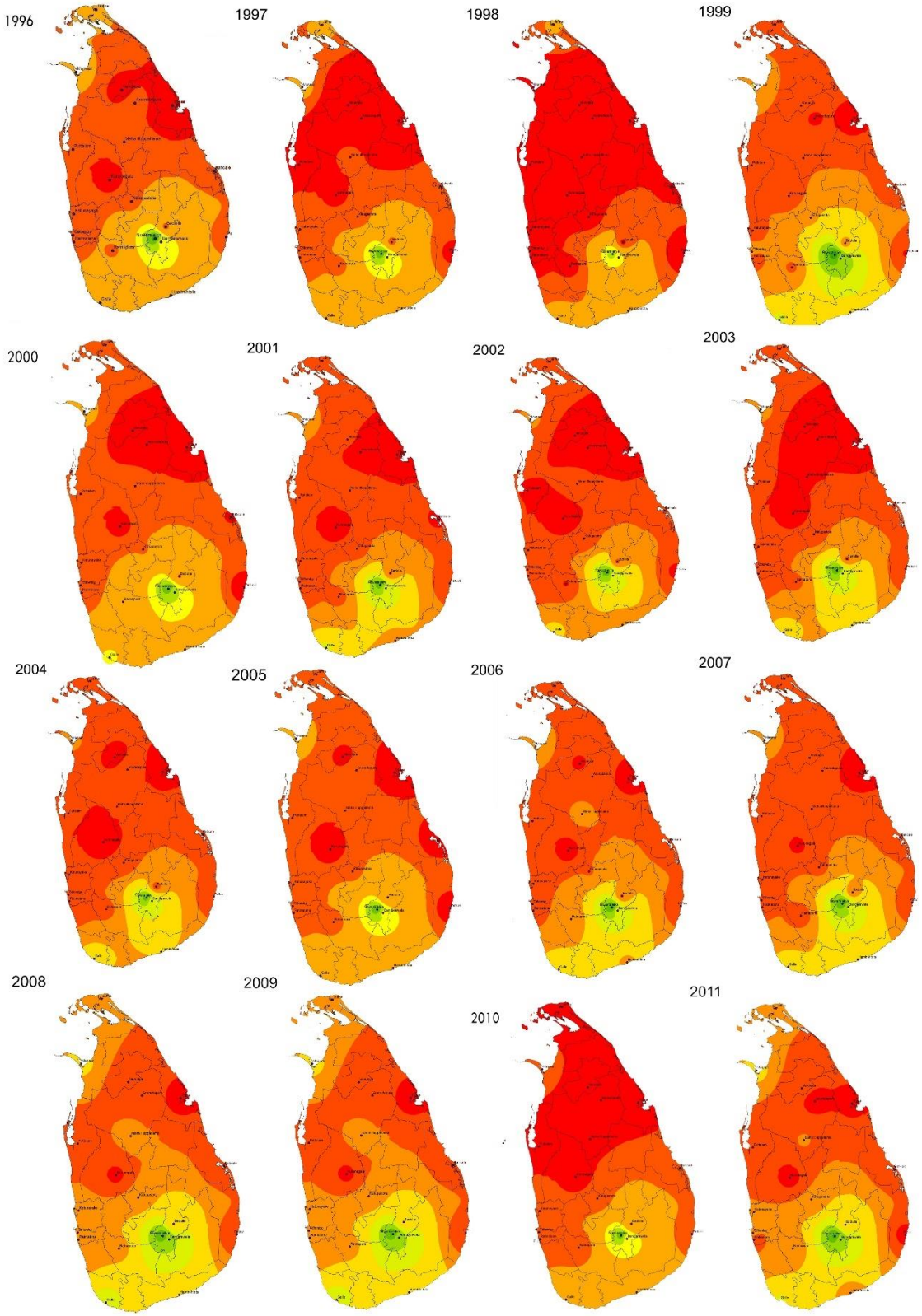
Name	Files	References
Exortation - shout out, convince, urge	5	40
Awareness	5	29
Public and professional awareness	3	18
Professional Awareness	1	7
Public Awareness	1	5
Promotion of public awareness	1	2
Educate people on the importance of environment	1	2
Create proper awareness amongst public and professionals	1	1
Lobbying environmental awareness on politicians	3	5
Professionals role in awareness and convincing of politicians	2	3
Create political awareness for politicians	2	2
Incorporating climate awreness in education system	2	3
Integrating climate awareness in school education system	1	2
Improve training and knowledge awareness	1	1
Awareness as the starting point for creating a change	1	1
Attitude change amongts student, professional and public	1	1
Incentivize	3	11
Rupees and Cents	2	6
Investor Awareness	1	3
Improvise poiltically and financially attractive solutions that are marketable (Nodes)	1	1
Improvise poiltically attractive solutions that are marketable	1	1
Incentivized and Penalized planning system	1	1
Implement Green rating systems - Point system	1	1
Commitment -act upon the word	4	30
Commitments - Documents to Practice	4	10
Adapting a feasible action plan for global commitments	3	5
Identifying the suitable policy actor for planning development	1	1
Set national goals to reduce temperature	1	1
Brige gap between documents and practice	2	3
Stengthen Enforcements	2	2
Professional Ethics	2	10
Professionals should design more responsibly	1	7
Design ethically	1	1
No commitment by professionals regarding environmental issues	1	1
Professional commitment on top of requlations	1	1

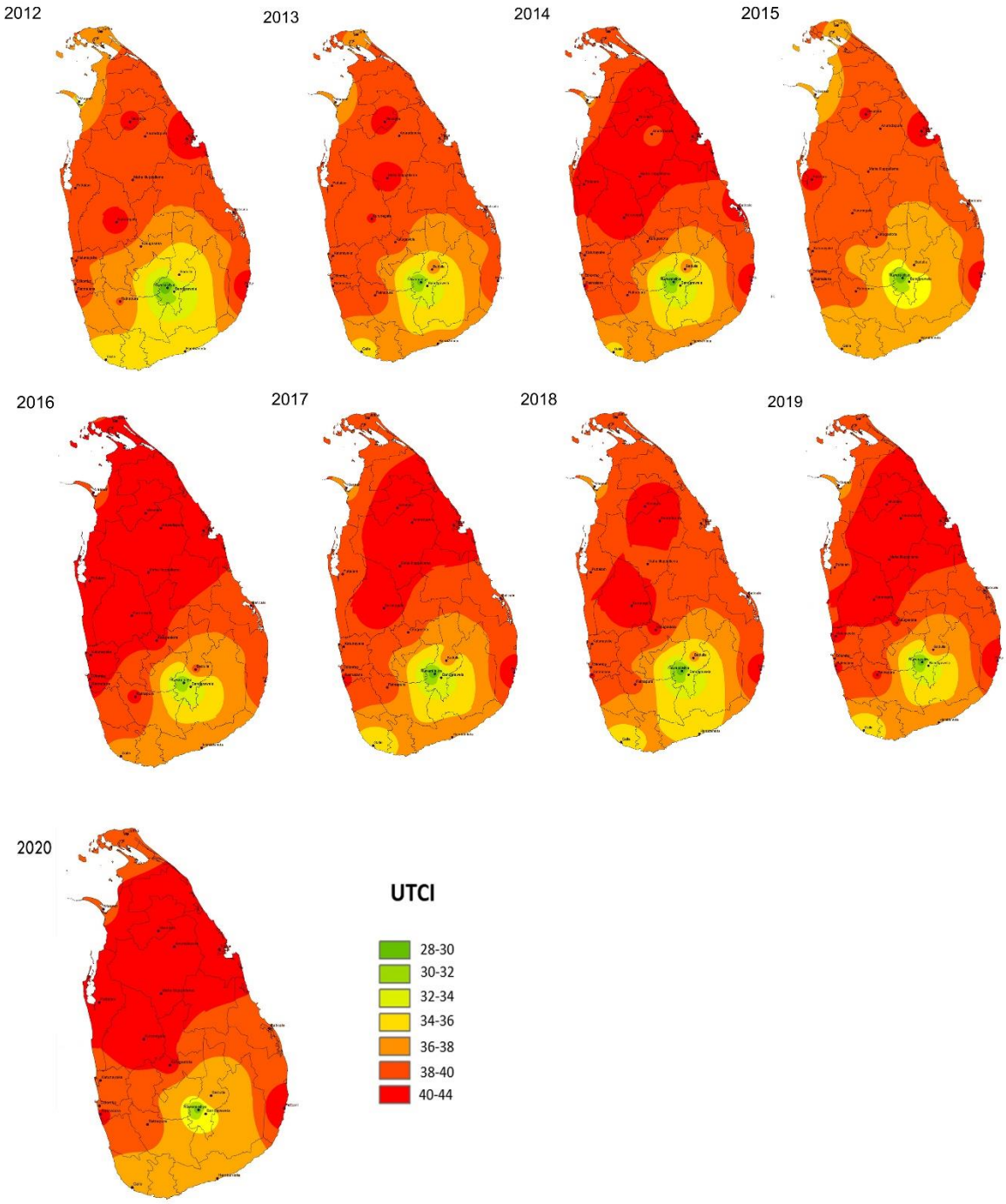
Name	Files	References
Professional Ethics	2	10
Professionals should design more responsibly	1	7
Design ethically	1	1
No commitment by professionals regarding environmental issues	1	1
Professional commitment on top of regulations	1	1
Political Will	3	8
Head of the government as the key influencer in bringing a change	1	3
Politics as a key element of planning implementation	2	3
Requirement for a proper government vision in guiding planning principles	1	1
Public commitment	2	2
Public will - equally important	1	1
No concious effort	1	1
Continuity - Rome was not built in a day	4	24
Periodical review	2	10
Change in planning model	1	2
Development plans to be updated every 10 years	1	2
Identify outdated regulations and update periodically	1	1
Plans to be amended for current context	1	1
Update development plans frequently	1	1
Updating planning documents once in every 10 years	1	1
Development plans to be amended as per current requirements	1	1
Development plans should cater the speed of societal advancement	1	1
Contnuity of policies despite regime changes	4	9
Government change and political instability	3	4
Political agendas influence in genuine attempts	3	4
Plan considering long term and gradual implementations	1	1
Inception to Completion - Audit	3	5
Check climate performance - climate audit	1	2
Insights - through research & data	5	23
Through research	5	9
Update - research and policy	2	4
Local specific climate studies to improve specific solutions	1	2
Lack of contextual research in academia -towards specific solutions	2	2
Localized research	1	1
Through data	3	8

Name	Files	References
Check climate performance - climate audit	1	2
Insights - through research & data	5	23
Through research	5	9
Update - research and policy	2	4
Local specific climate studies to improve specific solutions	1	2
Lack of contextual research in academia -towards specific solutions	2	2
Localized research	1	1
Through data	3	8
Recording, categorizing and storing data for future use	2	5
Acquire accurate realtime data	2	2
Develop local parameters for climate comfort	1	1
Through Precedence	1	6
Incorporate localized solutions inspired from international plans	1	3

Appendix 04

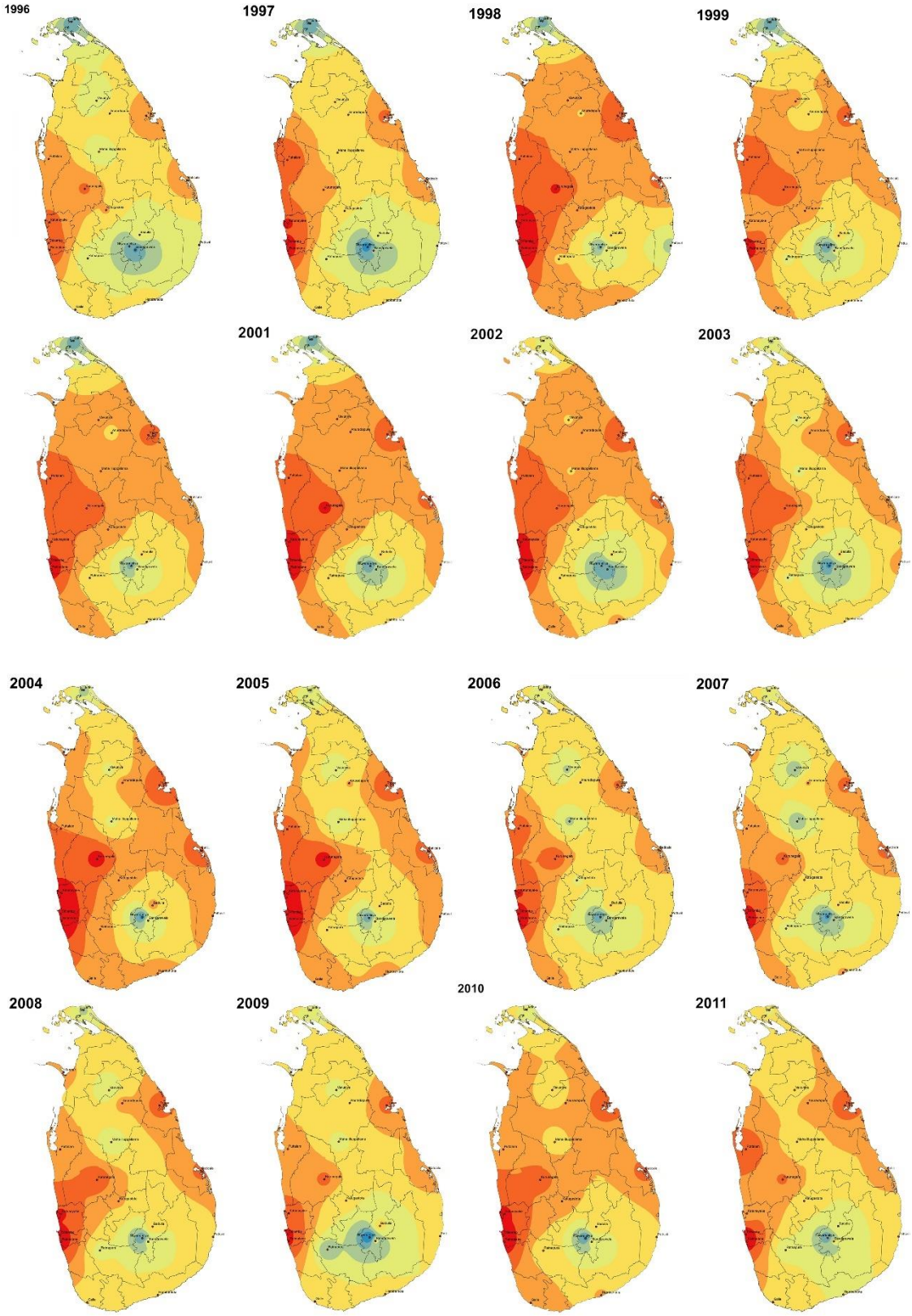
Thermal comfort trend in the hottest month-April

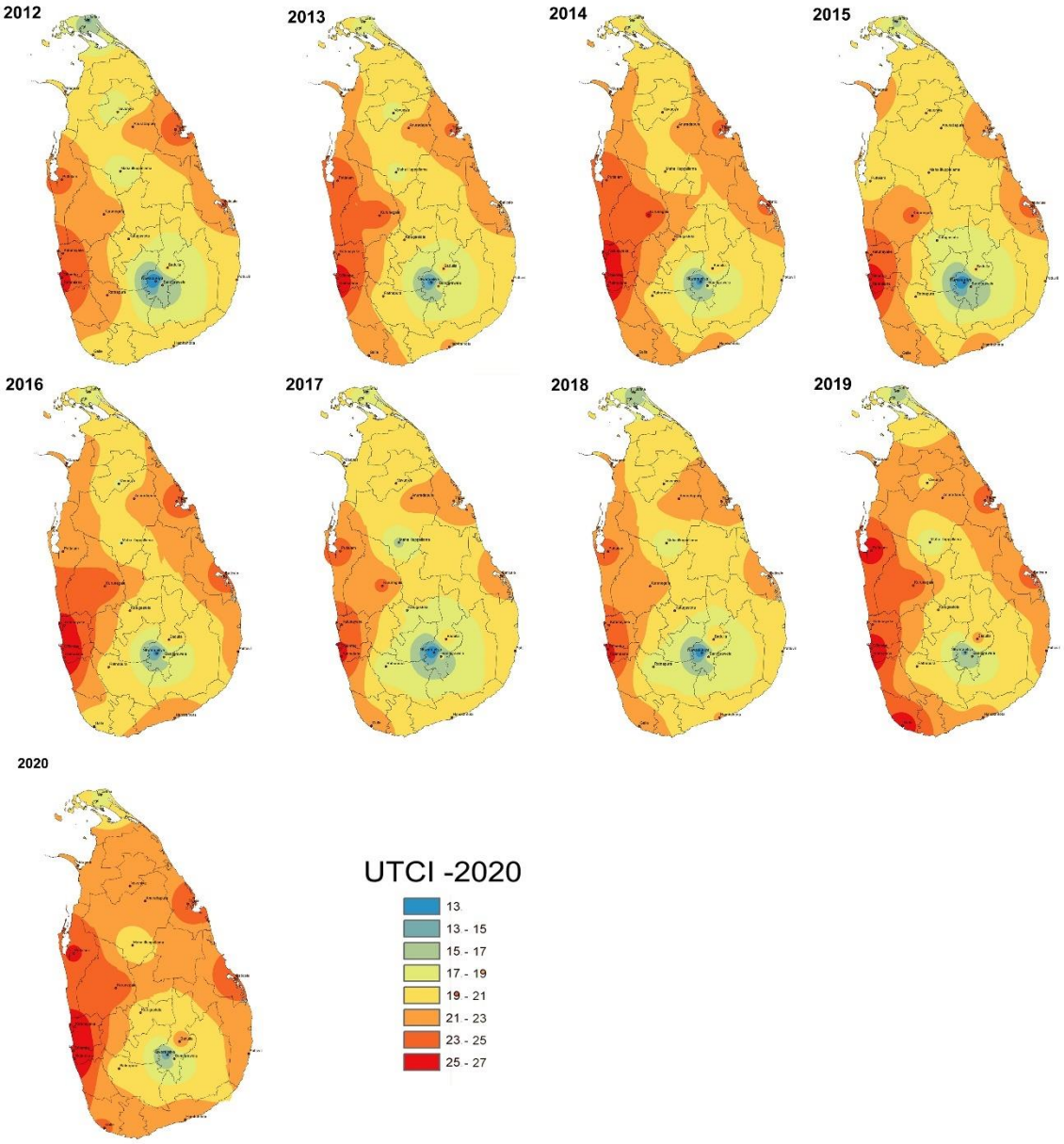



2012
2013
2014
2015
2016
2017
2018
2019
2020
UTCI
28-30
30-32
32-34
34-36
36-38
38-40
40-44

Appendix 05

Thermal comfort trend in the coolest month-January




2012
2013
2014
2015
2016
2017
2018
2019
2020
UTCI -2020
13
13 - 15
15 - 17
17 - 19
19 - 21
21 - 23
23 - 25
25 - 27

Appendix 06

C- form – Colombo Development Plan

Specifications for Development
Form C1

Row No	Minimum Land Extent (sq.m.)	Minimum width between building lines of a public Street/Road (meters)	Minimum width of private Street/Road (meter)	Maximum permissible FAR
1	150 less than 250	-	3.0	1:1.5
2	150 less than 250	-	4.5	1:1.75
3	150 less than 250	-	6.0	1:2.0
4	150 less than 250	-	9.0	1:2.5
5	150 less than 250	12.2	12.2	1:3.0
6	250 less than 400	12.2	6.0	1:3.5
7	400 less than 500	12.2	9.0	1:4.5
8	500 less than 700	12.2	9.0	1:5.0
9	500 less than 700	15.0	12.2	1:5.5
10	700 less than 900	15.0	12.2	1:6.0
11	900 less than 1000	15.0	12.2	1:7.0
12	900 less than 1000	22	12.2	1:7.5
13	1000 less than 1500	22	12.2	1:8.0
14	1500 less than 2000	22	12.2	1:9.0
15	1500 less than 2000	24	12.2	1:9.5
16	2000 less than 2500	24	12.2	1:10.0
17	2500 less than 3000	24	12.2	1:12.0
18	3000 and above	24	12.2	Unlimited

Revised Form C2

Building Category	Maximum number of floors including ground floor	Minimum site frontage (m)	Maximum Plot Coverage (%)	Open Space around the Building			
				Minimum Rear space (m)	Minimum one side space (m)	Both sides space(m)	
						Each Side Or	One Side
Low Rise	Ground floor	6.0	65	2.3	-		
	2	6.0	65	2.3	-		
	3	6.0	65	3.0	-		
	4	6.0	65	3.0	-		
Intermediate Rise	5	8.0	65	3.0	3.0 GF only		
	6	10.0	65	4.0	3.0 GF only		
	7	14.0	65	4.0	3.0		
	8	16.0	65	4.0	3.0		
Middle Rise	9	22.0	65	4.0	3.0		
	10	26.0	65	4.0	-	3.0 or	4.0
	11	30.0	65	4.0	-	3.0 or	4.0
	12	30.0	65	4.0	-	3.0 or	4.0
High Rise	13	35.0	50	4.0	-	4.0 or	6.0
	14	35.0	50	4.0	-	4.0 or	6.0
	15-20	40.0	50	4.0	-	6.0 or	9.0
	21 & above	40.0	50	4.0	-	6.0 or	9.0

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Source: UDA (2018)