UNDERSTANDING THE EFFECTS OF MICROCLIMATE ON THE BEHAVIOR OF PEOPLE IN URBAN PUBLIC SPACES

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Abstract

Humans by nature are social creatures, therefore the provision of public spaces for social activity is an integral part of urban design. The use of public space is also seen to have a positive impact on the health and well-being of people. The modern-day decline in urban public space usage is due to comfortable thermal environments being created indoors through the use of technology and advanced design principles. The primary focus of this study was to understand the effect of microclimatic conditions on the behaviour of people in outdoor urban public spaces, in order to identify design methods to create a more conducive environment.
A plaza and waterfront in the city of Kandy were identified as urban public spaces for this study. Physical observations, activity mapping, photographic surveys, thermal sensation questionnaires, 3D modelling, and simulations of the thermal environment were the methods used for data collection. The cross-analysis of data led to a better understanding that in tropical climates shade is not the only solution.
Air temperature and solar radiation greatly impact the use of urban public spaces and people adapt to environmental conditions by experience. Wind, shade, vegetation cover, and surrounding urban geometry also contribute to thermal perception. It was inferred that there was no one primary factor but rather the culmination of all factors in different ratios that causes the environmental temperature to morph and change, affecting the thermal comfort of a space. The results of this study are used to provide a design-based recommendation in order to achieve an optimum level of thermal comfort and provide design efficacy for urban public spaces.

Keywords: Microclimate, Behaviour, Urban Public Space, Thermal Comfort

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Introduction

Urban public spaces play a vital role in connecting people to one another and to various activities. They serve as places for social interaction, commerce, and connections to different parts of the city. These spaces also offer a variety of recreational, cultural, and sporting activities for the community to enjoy. When designed with features such as engagement opportunities and comfort, these spaces become successful and heavily utilized by the public. (Aljawabra, 2014).

Urban development in the 20th century brought about an increase in population density, which led to a greater use of motor vehicles and a negative impact on public spaces. However, there has been a renewed interest in public spaces in recent years, as highlighted by works such as Jane Jacobs' "Life and Death of Great American Cities" (Jacobs, 1961). In addition to shopping, public spaces are now also used for street vending and performing arts.

Thermal comfort plays a significant role in people's decision to utilize these public spaces. Microclimate conditions, such as temperature, humidity, and wind, can affect the thermal comfort of these spaces and impact how people perceive, consider and use them. Improving microclimatic conditions and enhancing thermal comfort in urban spaces can encourage people to spend more time outdoors. This can lead to an increase in social cohesion and potentially boost economic activity. (Aljawabra, 2014)

Despite the attention being given to increasing the human utility of urban public spaces, there is a lack of attention paid to the microclimatic conditions and more specifically the thermal comfort of the spaces and how that directly affects the urban fabric and usability of these spaces.

The research problem was 'the lack of understanding on how microclimatic conditions in outdoor public spaces affect human behavior'. The author selected Kandy as the city of study for this research due to its limited options for public spaces and the significant impact of thermal comfort on their usage. The chosen case studies are also in close proximity to one another, allowing for a more accurate analysis of the effects of microclimatic conditions on their usage. This eliminates other potentially influencing factors such as accessibility and nearby amenities.

The study investigated the impact of microclimatic conditions on the behavior of people in urban public spaces, with a focus on understanding how these conditions affect thermal comfort and usage. The study will examine how the urban fabric and surrounding buildings can alter microclimatic conditions and impact thermal comfort. The results of the study will provide insight for urban planners, designers, and architects to create more responsive and holistic designs for urban public spaces that take into account microclimatic conditions and morphology. The study could also be further expanded to include other cities and cross-compare case studies to understand how climate affects the use of urban public spaces.

Theoretical framework:

A conceptual framework was devised to guide the research to assist with analyzing and interpreting the data based on existing theories and models developed specifically for the study. It provided a lens through which the research question, hypothesis, and data can be understood and interpreted.

Urban Public Spaces & Microclimates

"First life, then spaces, then buildings – the other way around never works."
(Gehl 2001)

Outdoor spaces, such as parks, plazas and other public areas, play a crucial role in facilitating social interaction. Political theorist Michael Walzer, in his 1986 work, noted that these spaces serve as a "shared space among strangers – individuals who are not related, friends or colleagues

Public spaces are intricately connected to the functioning of cities; impacting political, social, economic, public health, and biodiversity outcomes. Adequately designed and maintained public spaces are essential for fostering a balanced and thriving urban environment (figure 1).

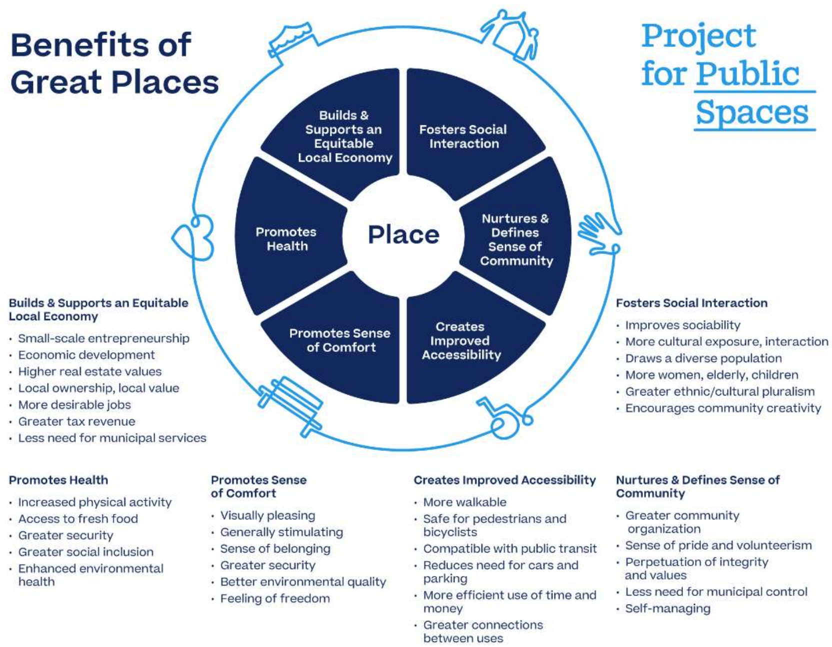

Figure 9: Benefits of great place (Project for public spaces,2000)

When designing urban public spaces, several factors are taken into consideration, such as enclosure and exposure, verticality and horizontality, mass, volume and light as described by Tuan (1977). Climate responsiveness is also a crucial aspect to be considered, as it can greatly impact the usability of the space (Gehl, 2011; Ashrae, 2010; Mclntyre, 1980). In order to implement effective climate-conscious design strategies, a thorough understanding of local climate conditions is necessary.

However, it is often observed that climate responsiveness is not given adequate consideration in the design of urban public spaces. Micro-climatological site selection is important as different sites may have vastly different climates, which can be studied and analyzed (Pressman, 1988, 30). By understanding how different biophysical landscape features create different microclimates, it is possible to improve site selection criteria to ensure that urban public spaces are located in the most favorable areas.

Microclimates, also known as local climates, refer to the specific conditions that individuals experience in their immediate environment, including variations in sunlight and shade, wind speed, and other characteristics. Urban microclimates refer to the specific conditions found in urban areas that can vary significantly from surrounding rural areas. These microclimates are influenced by factors such as the urban environment's geographical features, terrain, regional meteorological conditions, and human-made modifications to the landscape. These microclimatic conditions within outdoor public spaces directly impact the thermal comfort and usage of that space by individuals. (Dessi, 2002), (Nikolopoulou, 2001), (Zacharias J. S., 2001), (Zacharias J. S., 2004).

The spatial scale of microclimates

- Microclimates in cities are also governed by Spatial scale (Figure 2), introduced by Oke (1978) they are, Microscale refers to the surface energy balance of individual elements such as plants, buildings, and streets with land areas ranging from 0 m to 100 m.

- Local or neighbourhood scale, which refers to areas that cover 20 m to 10,000 m such as private gardens, streetscapes, and local public parks: and

- Meso scale refers to the city and regional climatic processes that occur across horizontal areas that usually exceed 10,000 m such as city-wide networks of parks, street trees, reserves, green wedges, and gardens.

Scale	Urban level	Horizontal distance	Vertical layer
Micro	Street canyons, squares, gardens	< 200 m–300 m	Roughness sub-layer
Local	Neighbourhoods	100 m–10 km	Inertial sub-layer
Meso	Cities	> 10 km	Mixing layer

Figure 10:- Types of scale, (adapted from Oke 1997)

As mentioned prior, scales do affect these conditions and it is also important to understand the vertical layers of urban climate (Figure 3) which are the urban canopy layer (UCL) and urban boundary layer (UBL) as they affect the climate within them. The UCL covers the areas between the ground and the building rooftops (i.e., buildings, gardens, streets, squares, and parks) and this is the layer at which humans reside. (Figure 4)

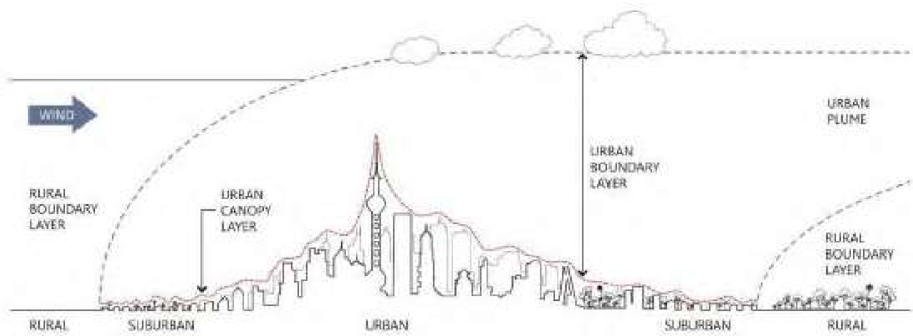

Figure 11: Conceptual view of the urban atmosphere at mesoscale Oke (1982)

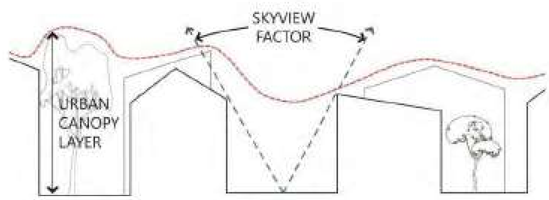

Figure 12: Conceptual view of the urban canopy layer at street scale. Oke (1982)

Urban Design and the Effect of microclimatic conditions

The design of cities has a significant impact on their climate, but the relationship between architecture and outdoor environments in cities has not been extensively studied. Traditional city design has focused on accommodating streets for vehicles, with little consideration for local climates, while indoor spaces have been made comfortable through modern heating and cooling techniques. This has also been applied to outdoor public spaces. However, designers should be aware that cities can create "urban microclimatic" conditions that affect user comfort and usage of urban spaces. Factors such as thermal comfort, urban morphology, building density, geometry, vegetation cover, and ground cover play a significant role in altering microclimates

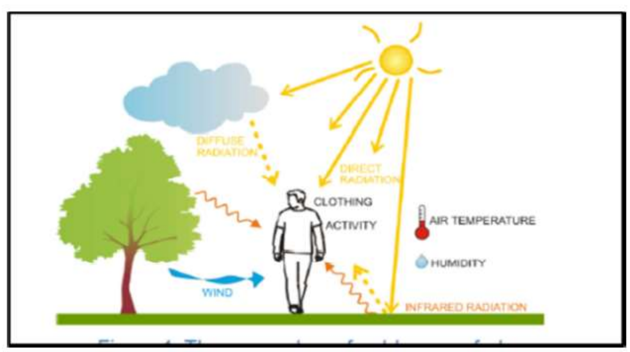

Figure 13: The parameters of outdoor thermal comfort (Perrineau, 2013)

ASHRAE defines thermal comfort as a person's satisfaction with the thermal environment, evaluated subjectively. Factors that influence outdoor thermal comfort include ambient temperature, solar radiation, radiant temperature, airspeed, relative humidity, clothing insulation, and metabolic rate. (Figure 5)

Researchers use the Physiologically Equivalent Temperature (PET) index, which was developed by Mayer and Hoppe in 1987, to assess thermal comfort. The index is based on the Munich Energy Balance Model for Individuals (MEMI) and measures thermal comfort in terms of physiologically equivalent air temperature (PET) at any given place compared to a typical indoor setting (80°F).

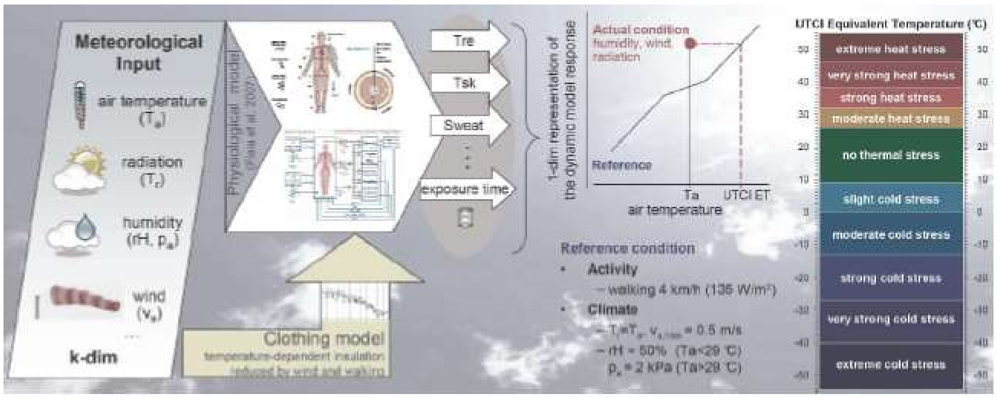

Figure 14: Concept of UTCI as equivalent temperature from the dynamic multivariate response of the thermophysical UTCI-Fiala model coupled with a clothing model (Brode et al.,2012)

UTCI (Universal Thermal Climate Index) is a highly advanced outdoor thermal comfort modelling tool that represents specific climates, weather, and locations and depicts temporal variability of thermal conditions better than other indices (Figure 6). It has been used in many outdoor field studies in recent years and has been calibrated with subjective thermal responses to gauge the thermal acceptable UTCI range for each thermal and user profile. UTCI has been suggested as a suitable planning tool for urban thermal comfort in urban neighbourhoods. (Blazejczyk et al. 2012 p.515)

Outdoor thermal comfort is also influenced by the ability of materials to absorb solar radiation, the arrangement of buildings and varying street geometries. Research has shown a difference of 7°C between sites in Colombo, Sri Lanka, due to street geometries (Johansson and Emmanuel, 2006).

Outdoor Urban Public Space and Activities

As much as we use public spaces, the way we respond to activities within them and how we conduct ourselves are responses not limited to our individual preferences only but to the space and the environment as a whole. Psychologist Kurt Lewin expressed this notion in 1951 **as B = f (P, E).** He stated that behaviour (B) is not only a function (f) of personal factors (P) but is also influenced by the environment of the space €. As mentioned previously the environment affects our thermal comfortability to which our behaviour responds.

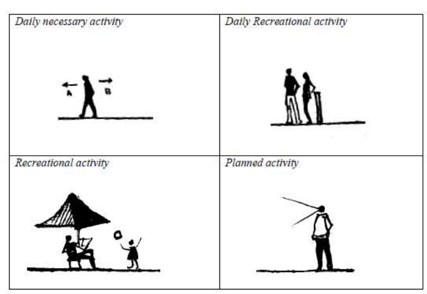

Figure 15: Different activities that can occur in public spaces, Author (2022)

An urban public sphere is a place where people often gather to relax or socialize and activities within it vary (Figure 7). Engwicht (1999) uses the term 'adult play' to describe the types of activities that adults often indulge in, and states that it is in public spaces that people's minds and imaginations react to the infinite stimuli with which they are faced.

Gehl (2001) in his book "Life between buildings" classifies outdoor activities into three categories: Necessary, Optional, and Social activities. The better the physical framework, the more activity that occurs within these spaces. This development can be measured by the number of participants, duration, and scope (figure 8). Gehl (2001) emphasized that the success of urban open space is not determined by the number of people or events, but rather by the number of minutes spent outdoors. To achieve this, Gehl (2001) suggests that more people and longer stay result in an elevated level of activity. He also points out that Optional and Social activities would occur only when the conditions in these external environments are suitable for an individual to stop and stroll.

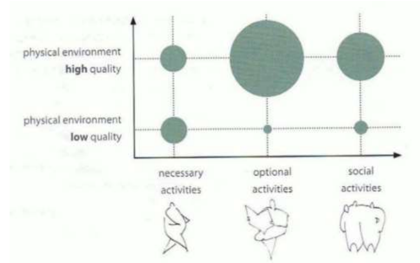

Figure 16: Jan Gehl's Condition vs. Activity Chart (Illustration) (Source: Cities for People, 2011)

Microclimates and urban public activity: the relationship

A study in Montreal, Canada, investigated the relationship between microclimatic conditions and the spatial behavior of users in urban plazas (Zacharias et al., 2001). The study measured air temperature, wind speed, time of day, presence or absence of sunlight, and proportion of surface area in sunlight. Researchers observed the usage of urban space by collecting data on total attendance, the number of individuals exposed to sun and shade, as well as types of activity engaged in. The study found that attendance in public spaces is directly linked to microclimatic conditions, with air temperature being the most important factor. (Aljawabra, 2014)

A study by Makaremi (2012) examined the relationship between climatic conditions and people's behavior in public spaces. The study used thermal indices to measure temperature, wind speed, radiation, and humidity, and also collected data through interviews and observations of users' behaviour with thermal imaging equipment. Similarly, Gehl (2001) in his book "Life Between Buildings: Using Public Space" studied how climatic conditions affect outdoor activity by observing the time people spend sitting on sunny and shady benches. People tend to adapt their behaviour to non-favourable conditions in order to adjust to their environment, these adaptations are known as reactive and interactive (Nikolopoulou and Steemers, 2003, p.97).

Reactive adaptation, as defined by Nikolopoulou (2011), refers to changes in posture made by individuals to protect themselves from solar or wind exposure for heating or cooling purposes. This type of adaptation is dependent on microclimatic conditions and is used to avoid discomfort. Interactive adaptation, on the other hand, refers to changes made to the environment by individuals to improve their comfort conditions. These methods are often incorporated in field observations and questionnaires to understand how people respond to their spaces, including factors such as wearing protective clothing or using shade umbrellas.

Thermal Comfort within the Tropics

Tropical regions, located at the edges of the Earth's tropic zones, have climates close to what is considered 'ideal weather year-round'. For example, Colombo, Sri Lanka (6.9°N and 79.87°E) experiences an annual range in maximum temperature of 30°C – 32°C while its annual range in minimum temperature is 22°C – 26°C. This compares favourably with indoor thermal comfort standards (24° ± 1°C).

In warm, humid climates, residents' perceptions of comfort are affected by long-term conditioning to hot temperatures and humidity. Clothing and personal habits are influenced by exterior conditions; so are expectations of comfort. A study of occupants of urban housing in Bangladesh indicates tolerance for extremely high humidity for comfort. The thermal environment in outdoor spaces in a tropical country is highly relevant to an individual's thermal perception. (Sharmin et al. 2012)

Thermally comfortable urban public spaces

Urban heat is a growing concern for cities worldwide, as temperatures rise and heat events become more frequent and extreme, along with the urban heat island effect. To address this, urban planners and managers must prioritize creating comfortable microclimates in public spaces. This not only improves the quality of urban life but also has far-reaching implications for building design. Currently, recreational open spaces are often poorly designed and do not consider climatological demands, resulting in poor user experience.

To achieve comfortable microclimatic conditions, it is important to ensure compatibility between local climatic influences such as air quality, noise, shade, temperature, solar radiation, humidity, wind, and rain. Studies in cities like Athens have shown a significant relationship between microclimate, outdoor space use, and solar radiation. Furthermore, research by Roberst-Hughes (2013) in England suggests that if 75% of the population walked for 20 minutes five days a week, 1 in 11 early deaths could be avoided annually, resulting in a savings of £900 million a year. This highlights the importance of creating comfortable and inviting public spaces for people to spend time in

Outline drawn from available literature

The literature review gave insight into urban public spaces, microclimates, the behaviour of people and activity that occurs in urban public spaces. It identified the link between the topics and formulated an analysis scheme through which the potential case studies could be evaluated to understand this better. The gist of the literature (Figure 9) seen below shows the connections between the topic

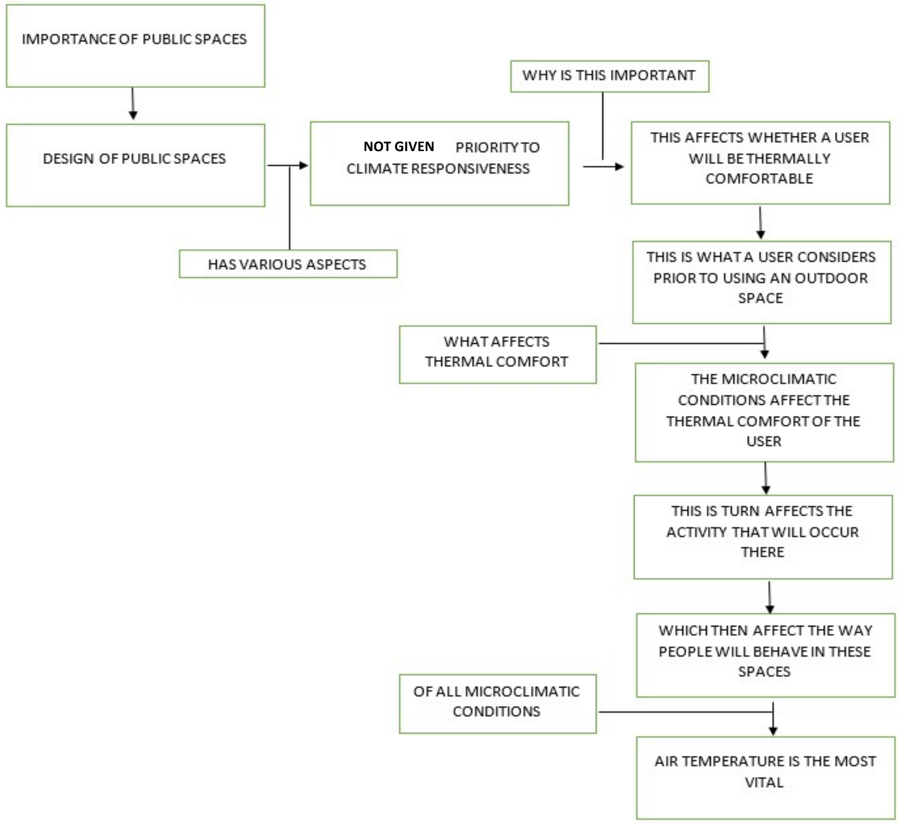

Figure 17: Summary of Available Literature, Author (2022)

Research method

Two public spaces were to be identified based on the criteria and users observed within the space were of a plethora of age groups. Additionally, subjects will be focused exclusively on the locals of the area, omitting tourists and temporary visitors. The sample would then represent the local culture of the studied area and the results derived would only reflect the focused area of study. (Figure 10)

Gehl (2001) mentions optional activities take place only when the external environments were suitable for an individual to stop and stroll linking the activities to the microclimatic conditions of the space. The author looks to map people that are sitting or standing within the chosen case studies.

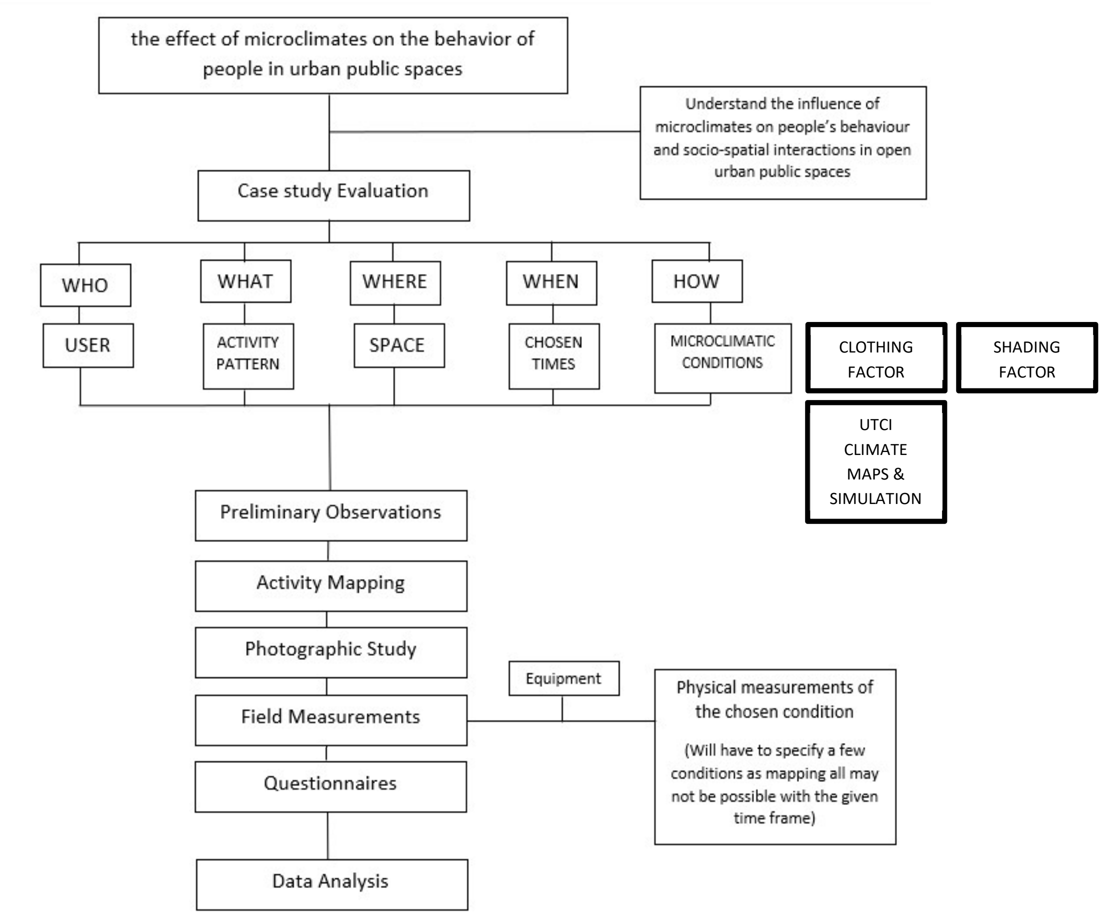

Figure 18: Research Method, Author (2022)

Kandy City & its microclimate: A summary

Kandy, a UNESCO World Heritage Site and the cultural capital of Sri Lanka, was chosen as the city of study for its unique topography and strategic location. Surrounded by three mountains and located at an altitude of 1640ft above sea level (Britannica 2022), Kandy offers a varied microclimate and the opportunity to study human behaviour in relation to topographical variations. The city's grid pattern and colonial architecture also provide a glimpse into its history and development. The topography of Kandy, and its location in comparison to a city like Colombo, also results in varying temperature differences within the city.

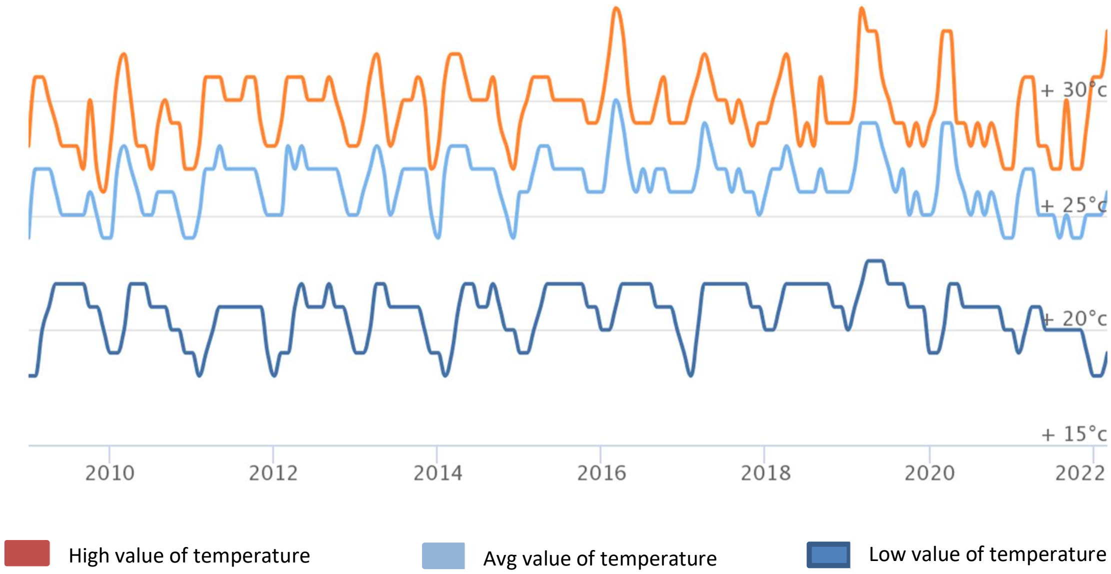

Figure 19: Variation in temperature from 2010 to 2021 (Met. Department, Sri Lanka,2022)

Records of air temperature values in Kandy from 2010 to the present were obtained and presented below (Figure 11). In 2021 the air temperature reaches maximum values around March/April and reaches the minimum in January. Throughout the year, a variation of around 8°C to 10°C can be seen from the high and low values of recorded temperature

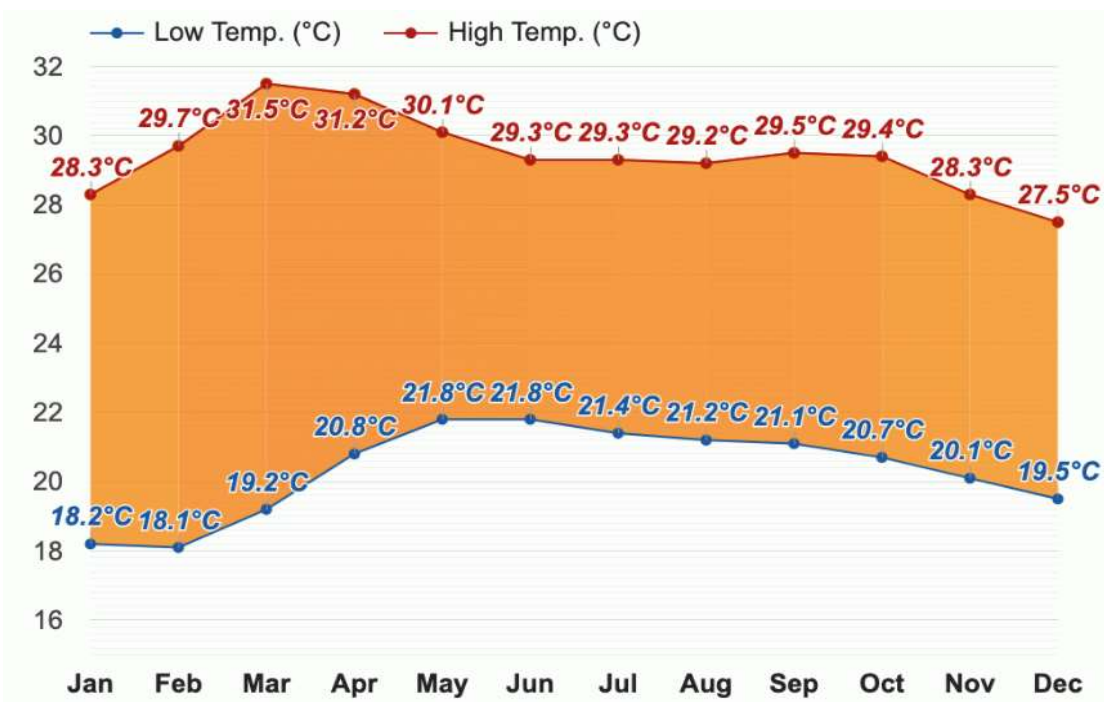

Figure 20: Variation in Temperature throughout the year 2021 (Met. Department, Sri Lanka,2022)

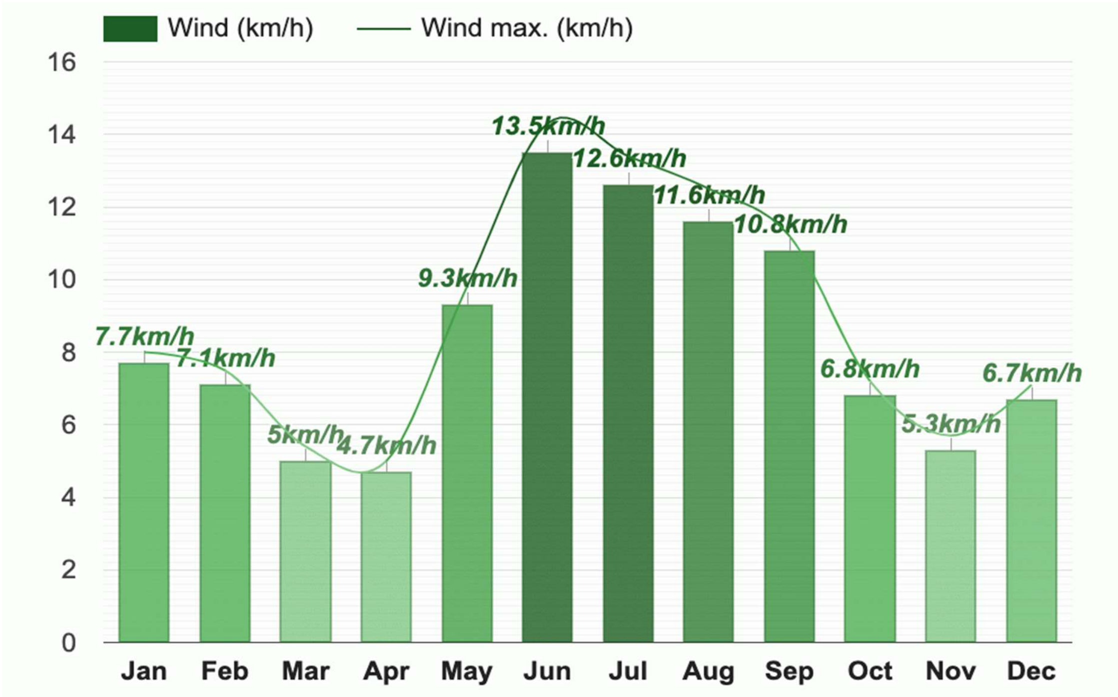

Figure 21: Variation in wind speed throughout the year 2021 (Met. Department, Sri Lanka,2022)

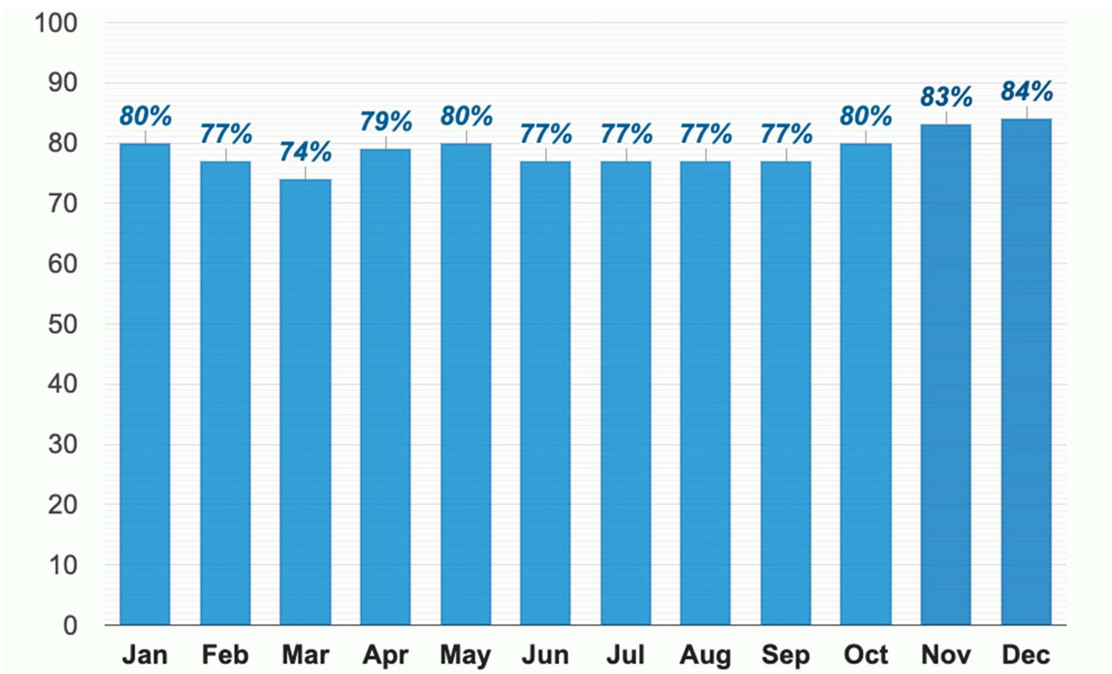

Figure 22: Variation in Humidity throughout the year 2021 (Met. Department, Sri Lanka,2022)

The temperature charts (Figure 12) help us understand that during the months of March and April, hotter values are expected. This factor coupled with low wind speed values (Figure 13) makes the aforementioned period feel warmer and hotter as the humidity (Figure 14) is relatively similar but the drastic low wind speed values coupled with the high-temperature values will make one feel quite uncomfortable outdoors. A higher wind speed could have negated a person's negative perception of the environment despite higher temperature values as sweat staying on one's skin would only be for a short while.

Case study selection

> *"Every time one leaves a building, he is exposed to an open space, and these include parks, plazas, streets, sidewalks, waterfronts, urban gardens, and natural areas."*
> (Gehl 2011)

Two case studies were selected to exemplify the above categories of urban public space as defined by Gehl (2001). The study found that different space typologies affect the use of space through the creation of different microclimates.

The chosen cases are from a single region to mitigate the role culture may play in how people of a particular area use the public space within that area. As Colombo features many urban public spaces and access and proximity of these may affect the use of the space, the city of Kandy was chosen as the area for the study ensuring participation from different socio-cultural backgrounds but from a single region. The city features limited urban public spaces and is frequented by many individuals for daily activity and leisure. The chosen areas to carry out the survey was primarily based on four aspects, which are:-

- Physical parameter variations – different sun and wind levels in the space allow people to select what they want to be exposed to.

- The choice of seating space with varied parameters offers a high variation of shaded/non-shaded and exposed to wind/sheltered from wind spaces for people to select to sit.

- The function of the space and how often it is used. It needs to be a space mainly used for sedentary activities, such as sitting and relaxing

- Scale and form that enables observation by a solo researcher

The chosen case studies were (Figure 15),

- The forecourt for the temple of the tooth (Plaza)
- The Kandy Lake round area (Waterfront)

Data collection involved both physical measurement (climatic parameter) and subjective survey (psychological perception). These were carried out simultaneously for the investigation of outdoor thermal comfort conditions. The study sampling was done on the 30th of April 2022. The afternoon time period was observed to be the warmest time and consequently more people adjusted their behaviour, opting to use particular parts of certain public spaces relatively more to be thermally comfortable.

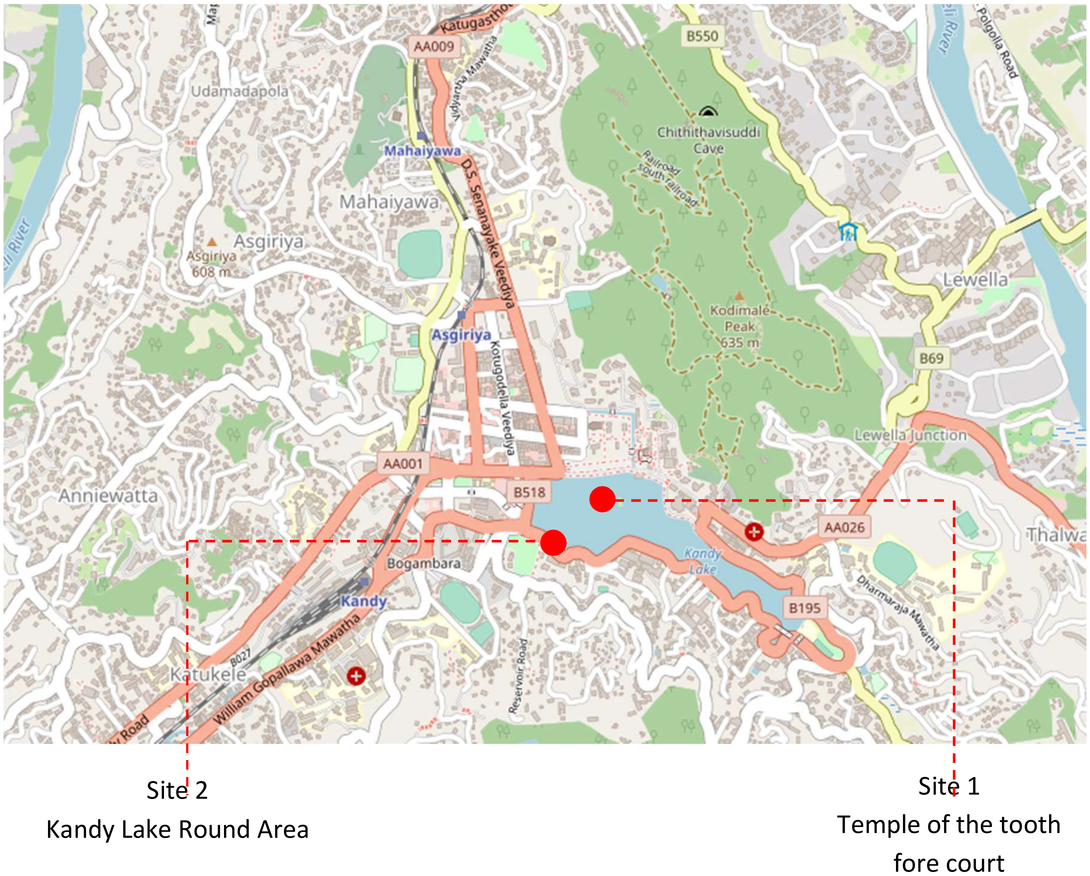

Figure 23: Map of Central Kandy, Sri Lanka (Openstreetmap, 2020)

Case Study Analysis

Site 1 - Forecourt of the temple of the tooth

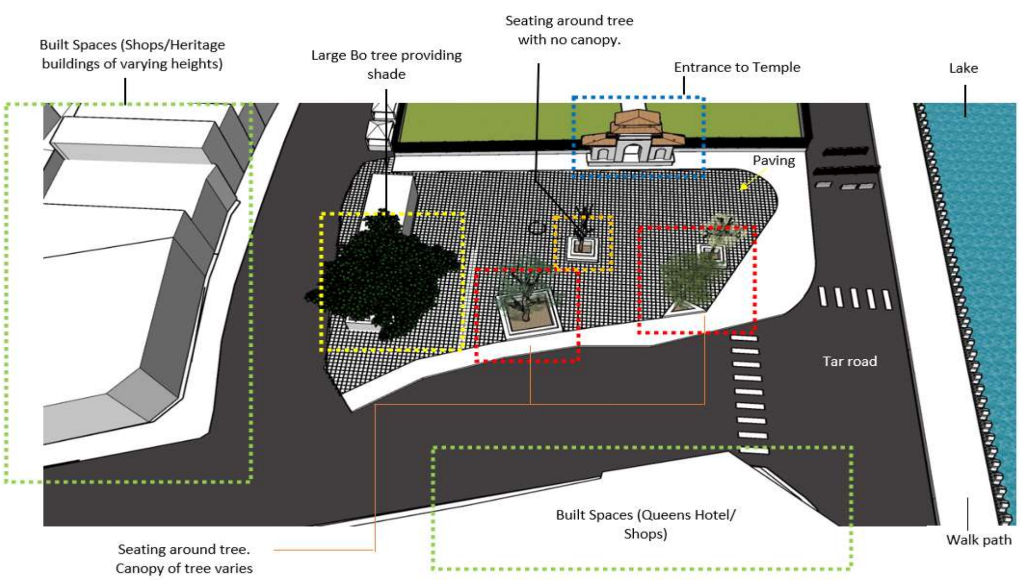

Figure 24: Elements of the temple of the tooth forecourt, Author (2022)

Located at one edge of the grid city this plaza also functions as an entrance to the temple of the tooth relic (Figure 16). Within the Grid City, there is no open space for recreation apart from this public plaza and it is frequented by many that are seen sitting, talking and strolling along or beside it. The site is wrapped by the built fabric on two edges. The other two edges open up to the 'Mahamaluwa' behind the temple entrance and the lake.

Figure 25: Images of site identifying elements (Image), Author (2022)

The plaza has an 85% paved surface which was preferred as it is an outdoor exposed surface. The paving stones are grey-coloured rubble tile. The surface is impervious and gives the space a dull, boring look and as seen in the images. Seating benches are located around trees at the site and are of varying sizes between 450mm to 500mm. Backrests seem non-existent with only the kerb around the planter provided. (Figure 17)

Shade is provided through trees at the temple entrance gateway. The surrounding built fabric does little during the observed time. Trees within have varying canopies with some quite bare. Towards the edge of the space, a tree was observed with a large canopy around which people are seen to gather frequently. People can be seen seated under areas of shade venturing out into the unshaded areas only while journeying to points across the space. However, the people moving across have also adapted, using umbrellas to shade themselves from direct exposure.

Figure 26: Accumulated behaviour of users in Temple Forecourt, Author (2022)

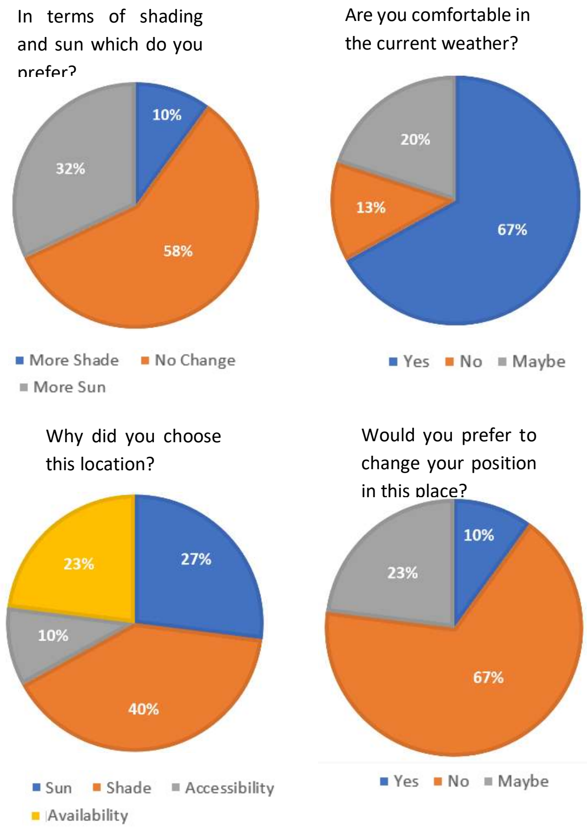

Figure 27: Questionnaire responses from users, Author (2022)

Above (Figure 18) is a cumulation of all the users of the site during the observed time. The Charts on the left (Figure 19) show that more than 75% of people want more shade and 0% want more sun. This is a predictable behavioural response in the tropics where the harsh sun is often avoided by all regardless of the space and activity. In terms of comfortability, users do not feel comfortable when exposed to the sun and their choice of seating positions at the site is marked with a preferential selection of shade marking solar exposure as a predominant factor in their choices. Due to most of the site being exposed to the sun, the resultant behaviour was that several individuals sought to change their seating locations in the space

Figure 28: 3D Representation of Accumulated behaviour of users in Temple Forecourt (3D Image), Author (2022)

The majority of users were identified at the corner of the site where seating and shade were both available. Parts of the site exposed to direct sunlight saw little activity and were limited to necessary activities such as walking as the setting was not suitable for optional and social activities. All activities centred around the presence of trees and fixed seating. The space is physically permeable, allowing visual access throughout the space and links to vegetation, the lake, and other amenities. The ease of movement explains why necessary activities took place throughout the space regardless of the thermal conditions of particular regions of the site. (Figure 20)

Site 2 - Kandy Lake round area

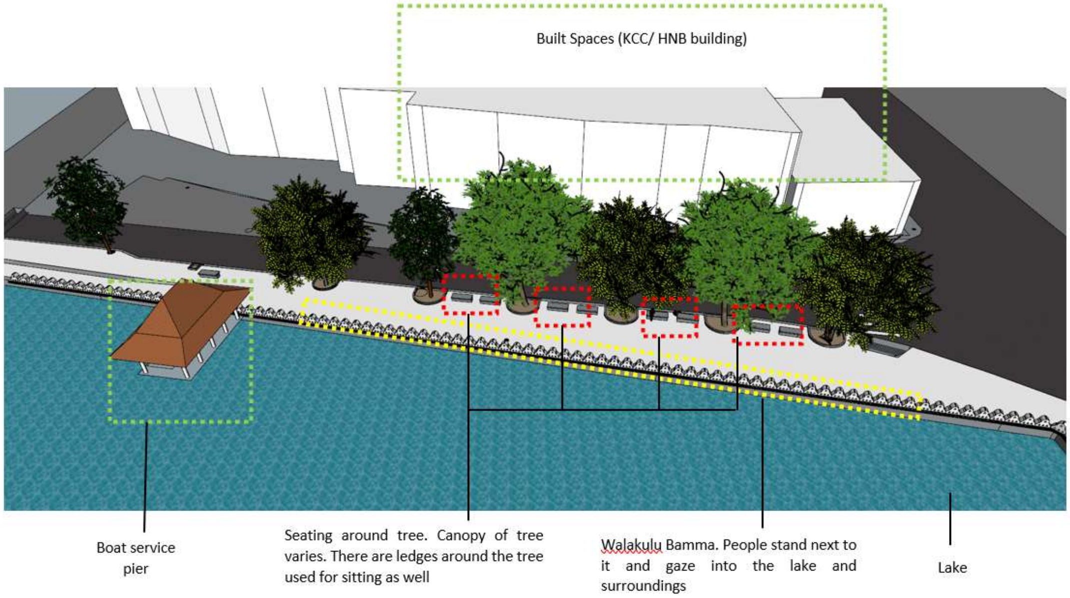

Figure 29: Elements of the Lake round area, Author (2022)

Kandy Lake, also known as Kiri Muhuda or the sea of milk, is an artificial lake in the heart of the hill city of Kandy. Built in 1807 by King Wickrama Rajasinghe next to the Temple of the Tooth it is a protected lake with fishing being banned in its waters. The area is a picturesque space with seating and is shaded by dense trees (Figure 21). Constantly frequented by visitors and vendors alike, it is a lively public space. (Figure 22)

Figure 30: Observations of usage of space (image), Author (2022)

The lake round area features a smaller paving block as opposed to the temple of the tooth forecourt. The area is covered by 65% with paving and shaded by large trees located at regular intervals. There are two seating benches located between the trees. People are seen alone or in groups, seated in several locations under tree-shaded and on the kerb around the soil, without modifications to their attire to protect from sun exposure. However, the people moving across the space have been seen using umbrellas to shield themselves from the direct sun. (Figure 23)

Figure 32: Accumulated behaviour of users in Lake round area, Author (2022)

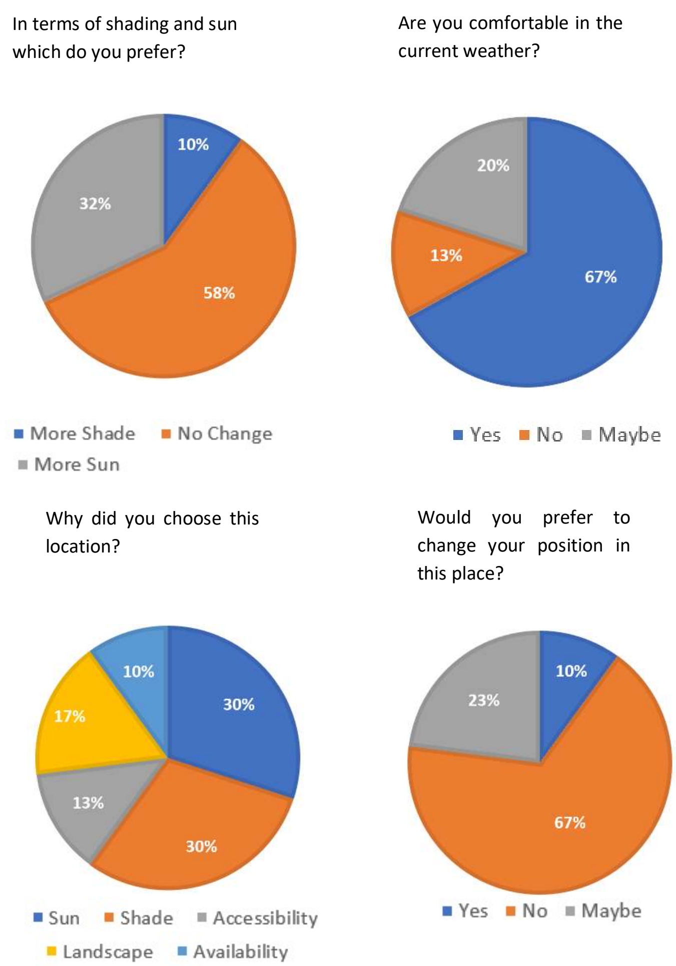

Figure 31: Questionnaire responses from users, Author (2022)

Through the graphs above (Figure 24) we can see a variation in the thermal sensation of the people within the site. In terms of shading, several users would prefer more sun which is in contrast to the first site where the desire for more sun exposure was 0%. Users here seem to be more comfortable in the space and many do not want to change their positions.

The choice of seating location is not picked predominantly due to shade as seen in the case before. The majority of the space here is shaded and that brings other factors into play in terms of seating choice.

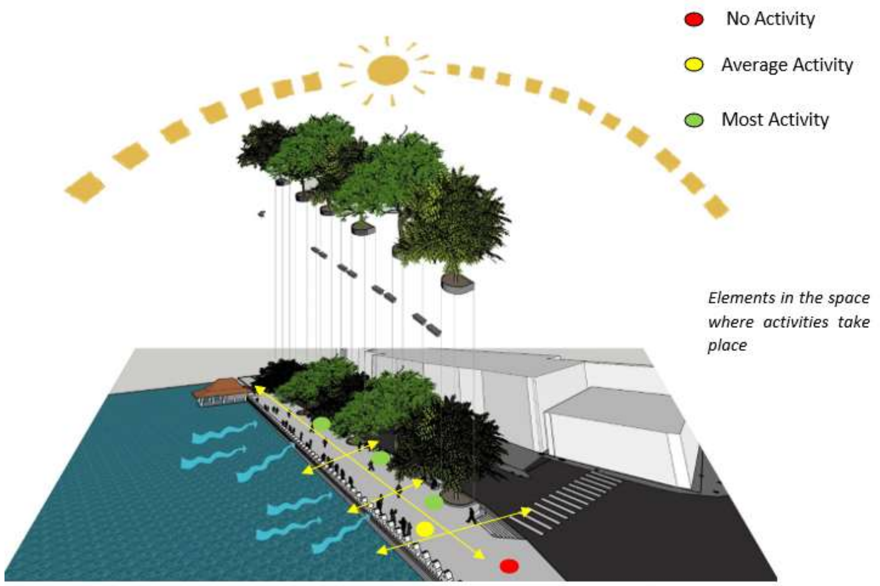

Figure 33: 3D Representation of Accumulated behaviour of users in the lake round area (3D Image), Author (2022)

Figure 34 : Ground cover and surrounding urban fabric of public space, Author (2022)

The linear waterfront strip is open to all sides and 90% of the space is shaded by trees with a dense canopy. Seating is provided through fixed benches and ledges located near and around the trees. (Figure 25)

Gaps within the space which were exposed to direct sun saw little to no usage and the regions that were, saw individuals shading themselves through the use of caps, umbrellas, etc. Social and Optional activities also took place within the space, as it has a desirable environment to both spend time in and socialize, as well as to visit due to the visually pleasant lake and surrounding greenery. (Figure 26)

The densely canopied trees provided ample shade throughout the day with a cool breeze from the waterbody, creating a thermally comfortable environment. This led to higher usage of the space. The users' choice of seating was influenced by the landscape, accessibility, and views rather than the amount of shade available, as most spaces were shaded. Only 10% of users desired to change their location, indicating that the space was already perceived as comfortable. This highlights the importance of shade in thermal comfort perception.

Cross case analysis

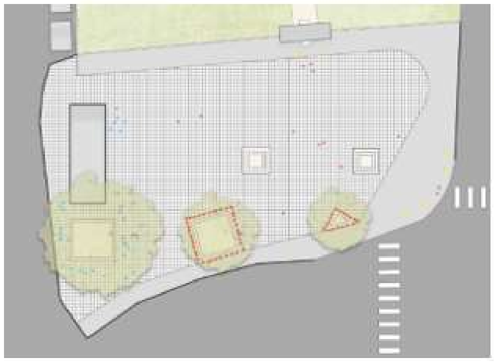

Figure 36: Activity map of Temple Forecourt, Author

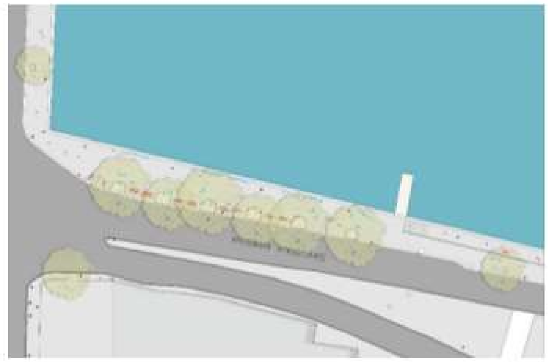

Figure 35 - Activity map of Lake round area, Author (2022)

The themes of thermal perception that were identified from the data collected and analyzed from the two case studies (Figure 27 & Figure 28) were evaluated and this led to a conclusion of their effect on the microclimatic conditions and the thermal perception of urban public spaces. The conclusions were then evaluated with the relevant literature to show a relationship between them.

Shade

The two case studies, located in proximity to one another, varied in terms of observed activities. This is due to the difference in microclimatic conditions at the sites. The level of shading within each space is directly linked to the amount of activity that took place. The Lake round had the most shading with nearly 90% of the site under the shade while the Temple of the Tooth forecourt had the least shading among the two, which can be directly correlated with the level and diversity of activity observed in the data. Therefore, it can be concluded that shade is a crucial factor in the microclimatic conditions that impact the utilization of urban public spaces.

Direct Sun Exposure

The correlation between microclimatic conditions and the use of outdoor spaces have been widely studied, with a particular focus on the impact of direct sun exposure on thermal comfort. Research has shown that direct sun exposure can significantly affect the use of space, with increased sun exposure leading to decreased activity levels and a lack of diversity in activities. This has been observed in a study of two sites in the city of Kandy, Sri Lanka, where a negative correlation was found between sun exposure and the diversity of activities within a site. Additionally, responses from questionnaires indicated that users at the Temple of the Tooth Forecourt requested additional shade or to switch seating, further indicating a lack of comfort in that location due to increased sun exposure. (Figure 29 & Figure 30)

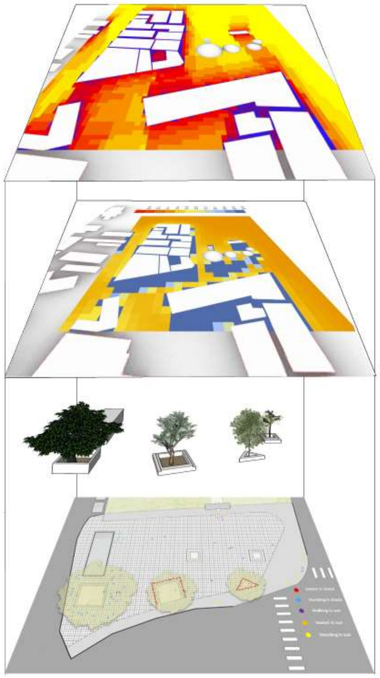

Figure 38 - Overlay of maps and elements of Temple Forecourt, Author (2022)

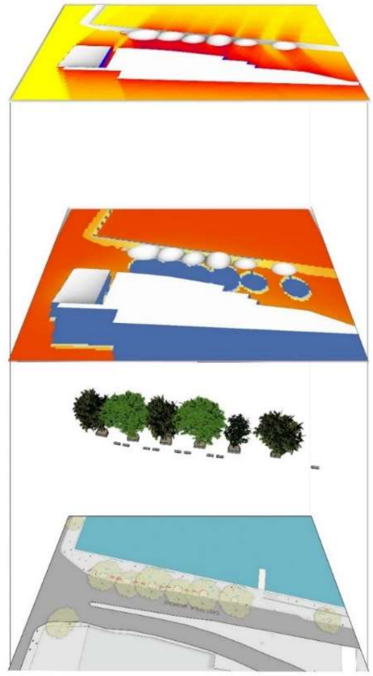

Figure 37 Overlay of maps and elements of Lake round area, Author (2022)

Surrounding built fabric

The facades of surrounding buildings can greatly impact the thermal perception of public space. The use of less reflective and detailed facades can reduce the reflection of sunlight and absorb heat, resulting in a cooler space. This is observed in the Temple of the Tooth Forecourt, where people tend to congregate near buildings with such facades. The built environment also plays a role in shading and airflow, where wind flow and sun exposure are balanced to create a comfortable space. The proximity to water bodies, such as the lake in the Lake Round area, can also enhance thermal comfort by providing a cooling breeze.

These findings support the findings of Oke (1988) and Arnfield (1990), who also concluded that outdoor thermal comfort in an urban neighbourhood depends on the ability of materials to absorb solar radiation and the geometrical arrangement of buildings.

Site Perception

The design and layout of a public space can greatly impact the users' perception of thermal comfort. Physical permeability, vegetation, and activity levels all play a role in the attractiveness and comfort of a space. High physical permeability, as seen in the lake round area, allows users to enjoy visual links to vegetation and surrounding spaces, making the space more attractive. However, poor visual permeability can negatively impact the level of activity in certain areas. Vegetation, such as trees, also plays an important role in providing shade and creating a more pleasant visual environment. In conclusion, the design and layout of public space, including the presence of vegetation and physical permeability, significantly influence the thermal comfort and attractiveness of the space for users. (Figure 31)

Privacy is an essential aspect of public spaces that greatly impact users' perception and comfort. Privacy can be achieved through various design elements, such as defined edges, natural elements, and elevation changes. Research has shown that spaces with higher levels of privacy tend to see a greater diversity of activities taking place within them. For example, the forecourt, which lacked defined edges, mainly saw necessary activities, while the lake round, which utilized a height difference to create a defined edge, saw more diverse activities and socialization. In conclusion, privacy is a crucial element of public spaces that significantly affect how users perceive and utilize them.

Vegetation plays a crucial role in shaping the thermal environment of urban public spaces. Research indicates that spaces with more vegetation tend to have lower air temperatures and higher levels of activity, which is consistent with the findings of studies by Dimoudi and Nikolopoulou (2003) and Gehl (2001). Microclimatic conditions, such as air temperature, wind speed, and sun exposure, have a direct impact on the behavior of people in urban public spaces. When coupled with elements such as vegetation, privacy, and permeability, these factors have a significant impact on the thermal comfort of users. This aligns with the research of Dessi (2002), Nikolopoulou (2001), and Zacharias J. S (2001, 2004) which supports the conclusion that microclimatic conditions play a vital role in shaping the behavior and perception of urban public spaces.

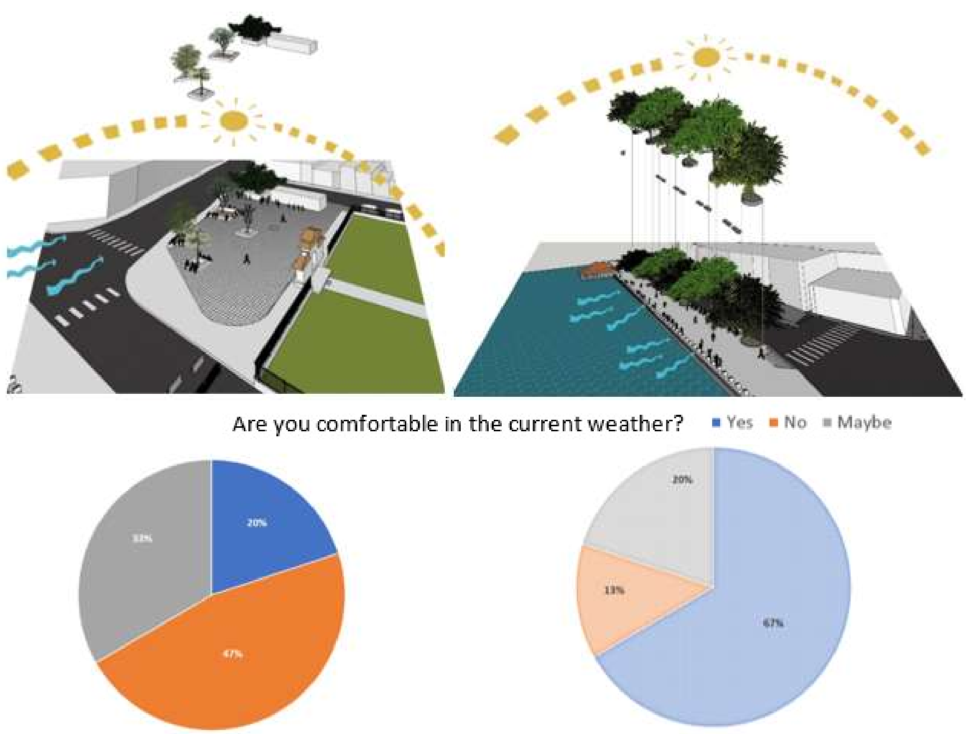

Figure 39: Physical attributes of each space and their perception, Author (2022)

Conclusion

This study aimed to investigate the impact of microclimatic conditions on the use of outdoor urban public spaces. The collected data provided insight into how people react to environmental and site conditions. The analysis of this data was used to identify the factors that influence people's perceptions and behaviour towards urban public spaces, based on the case study of two different sites. It can be broadly categorized that for an urban public space to be successful it needs to fulfil two key conditions.

1. Mitigating the effects of direct sun exposure
2. Creating a space that is perceived to be more pleasant

Sun exposure can cause thermal discomfort in outdoor spaces. The solution to this is shade, which can alleviate the exposure and make the area more thermally comfortable. The amount of shade and surrounding built coverage can be adjusted to change the microclimate of the space.

Dense, elevated tree coverage can effectively reflect the sun's heat and create a larger thermally comfortable area by reducing solar radiation. Additionally, utilizing wind and appropriate ground cover can prevent the ground from heating up quickly and maintain a cool air temperature.

The materials used in the construction of a site should be carefully considered as they can affect thermal comfort. Factors such as the reflectiveness and roughness of the surrounding buildings, as well as the specific heat capacity of the materials used for ground coverage, should be taken into account. High-specific heat materials will take longer to heat up and provide comfort during and after peak sun exposure, compared to materials with low specific heat capacity.

Wind speed and direction can impact the usage and comfort of public spaces. The surrounding built environment should be considered when selecting a site, as it can either enhance or hinder airflow, which can affect humidity and comfort levels. The location and level of wind flow and shade can also influence how people use and occupy the space, such as whether they gather in groups or alone.

The perception of the space is also important in thermal comfort as it is the subjective feeling the users have towards the site, which will influence their thermal perception. This can be manipulated by improving the pleasantness of the site through increased use of vegetation, flora, and fauna. In addition, the manipulation of light within the space to improve its visual appeal can also be seen to attract more people. Visual permeability is also important in making a space feel more pleasant as this will cater to the visual need of people that prefer a more open space to spend time in. Visual comfort is therefore another important aspect that can increase the utilization of urban public spaces.

This expands the choice of the utilization of natural light in the site without having to worry about the ground absorbing the sun’s heat and increasing the air temperature. It will facilitate the utilization of natural light as an instrument in the success of the urban public space and not as a fear factor.

Social factors also need to be considered for the successful adoption of urban public spaces. The level of privacy in the space will dictate the willingness of users to take part in diverse activities. If they feel that the space provides adequate privacy, they will be more willing to take part in group activities within the space. To promote the number of couples and private groups seen within the space, pocket regions should be provided to cater to their privacy needs which will increase the level of social activity within the space.

The involvement of external stakeholders, such as members of the municipality, is crucial in the development and maintenance of public spaces. This ensures that the social aspect of the space is developed and maintained by the local community. For example, events and social meetups such as charity events and pop-up marketplaces can be organized. Additionally, permanent food and beverage vendors can be established to attract people to come and spend time in the space. A visually appealing space that also provides privacy will attract a diverse group of people and incentivize vendors to set up shop. However, it's important to consider the site conditions such as shade and wind flow to mitigate the effects of direct sun exposure, in order to make the space more comfortable for people to stay for a longer period of time.

Recommendations for future studies can also be considered along the same two broad categories of sun exposure and visual appeal. When providing shade from sun exposure, it can be further studied if shade provided from natural sources like tree canopies is preferred over the shade provided by built structures. Further studies can also analyze if the percentage of shade cover can increase thermal comfort in different climates. When considering visual appeal, urban public spaces can be studied with respect to landscape architecture to identify how to draw people to certain features in public spaces by landscaping techniques.

'It is hard to design a space that will not attract people.
What is remarkable is how often this has been accomplished'.

William H. Whyte
(n.d.). https://www.pps.org/article/wwhyte

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