ASSESSING THE IMPACT OF VEGETATION CONFIGURATIONS ON THE SENSE OF SAFETY AND COMFORT IN URBAN GREEN SPACES OF SRI LANKA

Kawshalya LWG

198124F

Master of Philosophy

Department of Architecture

Faculty of Architecture

University of Moratuwa

Sri Lanka

August 2024

ASSESSING THE IMPACT OF VEGETATION CONFIGURATIONS ON THE SENSE OF SAFETY AND COMFORT IN URBAN GREEN SPACES OF SRI LANKA

Kawshalya LWG

198124F

Thesis/Dissertation submitted in partial fulfilment of the requirements for the degree

Master of Philosophy Thesis

Department of Architecture

Faculty of Architecture

University of Moratuwa

Sri Lanka

August 2024

DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of Higher Learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date:25th August 2024

The above candidate has carried out research for the MPhil thesis under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr DP Chandrasekara

25.08.2024

Signature of the Supervisor: Date:

DEDICATION

To the boundless realm of knowledge, which fuels our curiosity, shapes our understanding, and inspires the journey of discovery documented within these pages.

And to my late mom, whose dreams for me have always been my guiding light, though she never had the chance to witness the realization of this journey.

ACKNOWLEDGEMENT

First and foremost, I extend my deepest gratitude to my supervisors, DP Chandrasekara, Gamini Weerasinghe, and Janak Wijesundara, for their invaluable guidance, wisdom, and patience throughout this journey. Your expertise and encouragement have been the pillars upon which this thesis stands.

To my husband, Binushka Jayasanka, my partner in crime, who has always supported me and cheered me on, even in silence. Thank you for being the calm in my storm, the voice of reason to stop me when I wanted to throw my laptop out the window, and for never letting me forget that there's more to life than just research (like good food and company, for example).

To my family, my dad and younger brother, who probably still aren't sure if I'm done with this degree yet or not: surprise! It's finally happening! Thank you for your love and support, even if you had no idea what I was actually doing all this time.

A special thanks to my colleagues, Clarence, who consistently asked, "When will this be over?"—well, Clarence, we're finally here. Your persistence gave me a good laugh and a push to keep going. Nimali, my bestie and partner in all things, deserves a special mention. From countless late-night calls to endless cups of coffee, our gossip and venting sessions were the secret sauce that kept me sane. Thank you for being my emotional rock, my confidante, and the one who could always make me laugh even when things are tough. And Ahranya, my cheerleader, your unwavering positivity and celebration of my every little achievement have kept me going.

Lastly, to all those who have genuinely felt happy for my achievements, thank you for the good vibes and positive energy. You all made this rollercoaster of a journey a little smoother and a lot more fun.

ABSTRACT

The urban public spaces are often neglected and underused as a result of discomfort and lack of sense of safety perceived by the users while occupying these spaces. Urban green spaces play a vital role in providing both physical and psychological revitalization for the users in the midst of busy urban living. Exploration of the factors which leads to this anxious and distress feelings in users of urban green spaces is necessary for developing user friendly and sustainable urban public spaces. The current study aims to develop a self-assessment tool for assessing safety and comfort levels in urban green spaces and to evaluate the impact of vegetation configurations on sense of safety and comfort through a multiphase methodology. The self-assessment tool was developed through a focus group discussion following a principal component analysis done based on 174 responses from expert responses. The results generated an 18 variable self-assessment tool for determining levels of sense of safety and comfort. For the second phase 9 attributes were selected as the qualities of vegetation configurations. Out of these, visual hotspots and visual complexity are analysed through panoramic photographs and shade levels digital hemispherical photographs while degree of enclosure, degree of exposure, relative scale, view depth, visual permeability and physical accessibility were observed and measured onsite. These qualities were analysed with the sense of safety and comfort levels assessed through the self-assessment tool developed. A total of 1039 responses were collected (539 onsite responses and 500 online responses) and t-test results showed that there is no significant difference between the two categories. Thus, a stepwise linear regression analysis with both the categories of respondents showed that attributes visual permeability, sky visibility and degree of enclosure is associated positively while visual complexity, physical accessibility and relative scale is associated negatively with sense of safety and comfort. The outcomes of this study can provide better insights to the perception of the users which can be eventually used in designing and modifying better and user oriented urban green environments.

Keywords: Sense of safety, comfort, vegetation configurations, urban, green

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

3M-VAS	3M Visual Attention Software
AI	Artificial intelligence-
ANOVA	Analysis of Variance
CAD	Computer Aided Design (software)
BPQ	Body Perception Questionnaire
NPSS	Neuroperception of Psychological safety scale
PRS	Perceived Restoration Scale
PLP	Panoramic Landscape Photographs
DHP	Digital Hemispherical Photographs
COVID-19	Coronavirus
D_ENCL	Degree of Enclosure
D_EXP	Degree of exposure
P_ACS	Physical accessibility
R_SCL	Relative scale
V_DEP	View depth
V_PRM	Visual permeability
PAI	Plant Area Index
VEG	Vegetation
HP	Hotspot
CLR	Colour
PC	Principal Component
PCA	Principal Component Analysis
SPSS	Statistical Package for Social Sciences
USM	Ultrasonic motor
VE	Visual Elements
VIF	Variance Inflation Factor

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

By 2018, over half of the world's population (roughly 55%) lived in urban areas, and by the end of 2050, this number is predicted to rise to 68% (United Nations, 2019). Several nations are confronted with difficult circumstances as they attempt to meet the demands of their growing urban populations. In addition to basic needs like food and shelter, human motivation has become stronger than ever before due to concerns about social diversity, marginalization, and discrimination that have arisen with urbanization (Abrams et al., 2008). Not feeling connected or the feeling of exclusion from desired social groups or environments can create anxiety, depression, along with antisocial and aggressive behaviours (Abrams et al., 2008; Carter, 2002; Williams, 2004). This sense of anxiety is a major concern in the urban realm as this has resulted in the public spaces being neglected and unused (Mak & Jim, 2017). Public spaces are considered as the common infrastructure which ease the urban living (Force et al., 1999; Kweon et al., 2016a). Thus, transferring these urban public spaces, as spaces which doesn’t lead to anxiety or distress is a necessary step towards a successful management of the urban growth. According to a fundamental medical science diagnosis, this anxiety could be brought on by a person's clinical neurotic anxiety. However, taking into account the vast majority of people on the planet, it is determined that the most prevalent type of anxiety in most settings is realistic anxiety associated with a recognized trigger from the surrounding variables (Dillon, 2005). Numerous clinical and cross-disciplinary initiatives have been made to lessen anxiety and uneasiness (K. Andrews, 2019; Carter, 2002; Davis, 1999; Williams, 2004). This negative feeling when inhabiting urban spaces are due to various reasons including the unfamiliarity of the surroundings, the objects present in the surrounding or any other social incivilities woven with the particular space (Askari & Soltani, 2019; Carmona et al., 2010; Dillon, 2005; Hashim et al., 2016; Mak & Jim, 2017).

Previous studies show that the urban green environments are the stress releasing instruments within the close proximity to the urbanites (T. Chen et al., 2020; K.-T. Han, 2003; Tyrväinen et al., 2014; T. Yang et al., 2019). The rigorous experimental studies on the connection of the human with the nature explores that the natural environments indeed have the restoration capacities (Hartig et al., 1991; Hartig & Staats, 2006a; Kapferer, 1992; Ulrich, 1993). The views and surrounding elements of urban greens which enhance the positive emotions, physiology, health and cognition contribute most to the psychological and physical restoration from the daily stressful conditions of the urbanites (K.-T. Han, 2003). Additionally, research studies focusses on the contribution of the spaces like urban green spaces, urban façade designs and many other urban infrastructure to minimize the anxiety and stress in urban life (Dzhambov & Dimitrova, 2014; Maas et al., 2006; Mayer et al., 2008). Similarly, this research also contributes to the latter category which focuses on the urban vegetation and how it contributes to lessen or enhance the social anxiety and distress of the urbanites. The assurances of sense of safety and comfort of an individual tends to lessen the aforementioned anxiety while inhabiting public spaces. Considering all above-mentioned facts, this research focuses on exploring the impact of vegetation configurations on the feeling of safety and comfort which eliminates the anxiety and distress experienced by users.

1.2 Research Problem

As a result of urbanization, many people start to migrate into the urban areas and neighbouring suburbs from rural areas and consequently, the built mass of the areas tend to increase with the increasing population (Sanyaolu & Sanyaolu, 2018). Considering the world population, south Asia is considered as the region with most densely populated urban areas (Sarkar et al., 2013). Thus, the greenery of the urban areas suddenly converts itself to accommodate the living of these migrants. Due to the increasing stress in the busy lifestyle of the urbanites; they start seeking spaces for relaxation inside the cities of their residence. But unfortunately, by that time most of the relaxing greeneries has been converted into concrete masses (Hussain & Imitiyaz, 2018). Many south Asian countries try to protect their urban greens to a feasible extent by inducing laws and practicing conservation of green mass in the urban limits (Sharma, 2012). A few such green spaces remain in proximity in the urban areas as a result of conserving those spaces as conserved green patches. Out of these spaces only a few looks pleasing or habitable while others don't seem to be fit for the use of the urbanites. The reason is the different feelings or auras given out by different spaces (Shepley et al., 2019). The elements in the different spaces and their arrangements can bring out different feelings to the users (Lis et al., 2019a; L. Liu, 2020). These feelings will eventually lead to the neglection of spaces. According to numerous research, unlike the man-made structures, natural environments bring out more suspense due to the unpredictable arrangements. No matter how much the designers attempt, the natural environments are hard to arrange as intended when compared with the built structures (Kuo & Sullivan, 2001). As a result of this many researchers are being conducted on assessing the impacts from nature on the perceived safety and comfort of the users (Hashim et al., 2016; Jansson et al., 2013; Kuo & Sullivan, 2001; Lis et al., 2019a) as a way of reducing the anxiety in urban public spaces. However, it should be noted that, there are a limited number of research studies carried out in the context of tropics. The unique environmental conditions in the tropical areas and the cultural difference of the people living in these areas create a knowledge gap which should be explored through focussed studies (L. Kawshalya et al., 2020).

Subsequently, this study focuses on the question why people feel uncomfortable, unsafe, feel out of place, anxious or uneasy when using certain green spaces in the urban public areas of tropical contexts. The connection of these feelings to the vegetation configurations in the urban green spaces is also to be explored through this study. Thus, the following research questions are being focussed through this research.

1.3 Research Questions

This research study focusses on exploring the answers to the major research question "What is the impact of different vegetation configurations on the psychological aspects of safety and comfort in the urban green spaces?". Focusing on this major question, the following sub-questions are also to be answered through the study.

- How can the levels of sense of safety and sense of comfort in urban green spaces be effectively measured?
- What are the key dimensions and attributes that contribute to the sense of safety and comfort of the users in urban green spaces?
- How do different qualities of vegetation configurations impact on the sense of safety and comfort of urban users?

1.4 Research Aim and Objectives

The aim of this study is to evaluate the contribution of the vegetation configurations in urban green spaces in assuring a sense of safety for the tropical urban users.

1) Identify the variables which are applicable for the assessment of the psychological constructs of safety and comfort.
2) Identify the attributes/ qualities of vegetation configurations which impacts on the sense of safety and comfort in urban green spaces of Sri Lanka.
3) Investigate the objective methods of measuring the qualities of vegetation configurations (selected attributes) in urban green spaces.
4) Develop a self-assessment tool for examining the levels of sense of safety and comfort in urban green spaces in tropical cities.
5) Evaluate the impact of vegetation configurations on the sense of safety and comfort in urban green spaces using the selected case study.

1.5 Research Method

This research intends on exploring two main aspects as development of self-assessment tool for measuring levels of sense of safety and comfort in the urban green spaces and exploring the impact of qualities of vegetation on the sense of safety and comfort using the developed tool. Both the tasks will be initiated through a thorough literature survey focussing on latest research trends. A conceptual framework is developed based on the explored literature for both aspects. The whole research study will follow a multi-phase method where the development of self-assessment tool will be achieved through a sequential exploratory method (quantitative method following a qualitative method) and the impact assessment will follow a concurrent embedded descriptive method (quantitative and qualitative methods will be simultaneously carried out). The self-assessment tool development will be done through a survey with structured questionnaire following a focus group discussion. The impact assessment will accommodate stimuli-based analysis and physical measurement analysis of the qualities of vegetation configurations. Then the relationship between these qualities will be assessed along with the responses from general public which examines levels of sense of safety and comfort in urban green environments (which will be explored through the pre-developed self-assessment tool).

1.6 Scope and Limitations of the Research

The urban green environments have been selected, as urban users seek the psychological relaxation in these spaces. Thus, keen concentration on these environments in the midst of the urban context is more meaningful for this study. Although the initially collected literature suggests that there are numerous causes for the sense of safety in the urban context, like the age, disabilities, physical environment, socio cultural variables, economic variables, gender and many more. But the author has selected the vegetation configurations as the main focus for this study as it can affect in numerous ways depending on the qualities suggested through different arrangements. This is mainly because the most frequent element in urban restorative environments in Sri Lankan context is the vegetation, and the different arrangements of these vegetation have conveyed different feelings to the users. The study has selected a variety of methods for assessing the qualities of vegetation making this, one of the timely research projects in the domain of knowledge. Apart from the selected methods for assessing the qualities of the vegetation, there can be much more comprehensive methods. But the author tries to accommodate the conventional methods (measuring and observations) to latest simulation methods (software-based analysis) in the field of visual perception studies with the limited budgets and the limited technological advancements in the context of Sri Lanka. These different methods are chosen with the limited resources as an act of providing an insight to the practicality of simulation-based analysis in perception-based studies. Moreover, the daytime features related to the vegetation configuration is selected as the attributes for the study. Although it is noted that the nighttime features affect equally for the sense of safety and comfort, nighttime features rely more on the lighting and the respective visibility, rather than the vegetation features. Thus, nighttime safety of the park premises is not considered for this study.

Further, it should be noted that the qualities of the environments are decided based on the existing spaces of the selected case study of Vihara Maha Devi park, Colombo, Sri Lanka. There is no attempt in this research to cover a range of qualities like from mock setups or photo manipulation methods. This means if the enclosure levels of the selected spaces range from 0 – 50%, then the author has made no effort to assess the levels from 50 – 100%. Thus, the discussion has mentioned this very clearly when necessary. This is done since the author expects a genuine response from the users while actively using these spaces. The manipulated spaces might infuse different emotions than the naturally existing spaces. Furthermore, this study has increased the number of responses as possible to decrease the impact from the subjectivity of the users. The differences between the backgrounds of the respondents are not considered for analysis. However, it is impossible to remove the subjectivity in social science research, thus increasing the number of responses were selected as a practical attempt in this study.

1.7 Research Significance

The literature analysis has revealed that the most frequent and recent concerns are based on the vegetation and the other relevant aspects of the vegetation. Similar to the recent research trends, this study attempts to accommodate new research methodologies and techniques suggested in recent research articles. This confirms the timeliness of the concerns with the vegetation in the studies done on sense of safety. Similarly, this exploration has revealed that there is a limited number of studies carried out on the field of sense of safety in the tropical countries like Sri Lanka. Accommodating universally accepted research techniques and methodologies on to the context of Sri Lanka reveals whether these methods have a possible application in the tropical contexts as well. In the Sri Lankan it is rare to accommodate the user inputs while designing and adapting the urban public spaces. All these confirms the significance of this research which focusses on the psychological aspect of safety with regards to the different arrangements of the vegetation in urban public spaces.

CHAPTER 2

LITERATURE REVIEW

2.1 Sense of Safety and comfort

A person's comfort level and sense of risk in their surroundings can be the simplest definition of their sense of safety, and these play a significant role in people's overall well-being (Jansson et al., 2013). According to Fegan (2011), the feeling of safety stems from "humans' need to have control over their environment, to know where they are in space and in time, and to not be socially or physically lost". Sense of safety, often termed as perceived safety, psychological safety; is a prerequisite for the well-being and the improved quality of life of an individual (Blöbaum & Hunecke, 2016; Green et al., 2002). Different to the actual safety; sense of safety of a particular environment is a feeling experienced by individuals and directly connected with the fear of crime and the perception of risks in the immediate environment (Jansson et al., 2013; Salesses et al., 2013). According to recent research, feelings of safety, which imply psychological aspects of safety, are linked to emotional state, life satisfaction, and cardiometabolic health (Bennetts et al., 2017; Mouratidis, 2019). Although sense of safety does not refer to an actual threat in the environment, still its impact on the behaviour of an individual is difficult to ignore (Blöbaum & Hunecke, 2005). This sense of safety affects behavioural patterns of the individuals where; high sense of safety creates preferences and low sense of safety will create avoidance (Blöbaum & Hunecke, 2005; Z. Li & Yin, 2018). It was explored that the sense of threats and risks are negatively involved with the physical and mental health of the people (Jackson & Stafford, 2009; Stafford et al., 2007).

Comfort will eventually be attained at higher perceived levels of safety. Similarly, the word 'comfort' is also being used frequently in the studies which concern the social anxiety and distress (Dillon, 2005). As comfort is both physical as well as psychological, it is better to have a comprehensive idea to distinguish the difference. Physical comfort mainly concerns the physical environmental conditions and the satisfactory experience to the user. Psychological comfort is mainly about the subjective perception of being in safe and well-being and concerns more on the emotional integrity (Pineau, 1982). When considering the psychological comfort in urban areas; convivial urban spaces, spaces which bring happiness, pleasure, joyfulness have been discussed more often (Francis, 2009; Sepe, 2017; Shaftoe, 2012). Psychological comfort has been discussed with the positivity and the well-being which impacts the increase in the quality of life of the urbanites. Positive psychology has focussed on the positivity or positive feelings like joyfulness, pleasure, happiness for overcoming negative feelings like depression and suffering (Talepasand et al., 2016).

To create a user-friendly and comfortable urban public realm for users, researchers in the domains of urban design, landscape architecture, and architecture have been working on developing designs with higher levels of perceived comfort and sense of safety (Hashim et al., 2016).

2.1.1 Factors Associated with Sense of Safety and Comfort

Research is conducted throughout this domain examining the relationship between different elements or factors. As Van Winsum-Westra and De Boer (2004) states, sense of safety and comfort can be both objective as well as subjective; where the objective aspects are measured by the facts and the figures and the subjective aspects are the perceived safety and comfort experienced by a particular individual (Maas et al., 2009). Similarly Blöbaum & Hunecke (2005) states that the sense of safety and comfort can be achieved by addressing the socio-demographic features or psychological variables which leads to perceived danger (Cobbina et al., 2008; Fox et al., 2009; White & Farrell, 2006) and by emphasizing the physical cues which leads to perceived danger (Haldun Muderrisoglu & Zeki Demir, 2004; T. Herzog & Chernick, 2000; Mambretti, 2011). It is evident that an individual's sense of safety is influenced by both internal or perceptual factors and external cues.

The most common demographic factors which are discussed in the studies related to the perceived safety and comfort is the age (Boström et al., 2013; Kweon et al., 2016b; Pun et al., 2018) and the gender (Abas & Broadhead, 1997; Koskela & Pain, 2000; Pain, 1997). When age factor is assessed, it is examined that the elderly have a higher sense of danger than the young, although the victimization rate is low for the elders (Dogrusoy & Zengel, 2017). And also, it is explored that irrespective of the age, women feel a high sense of insecurity in public spaces than men (Abas & Broadhead, 1997; Gilchrist et al., 1998; Hashim et al., 2016; Morgan et al., 2018). Apart from these, many demographic factors like education (A. Jorgensen et al., 2007; Scarborough et al., 2010), income levels (Westover, 1985) has also been examined with the sense of safety. Perceptual or personal factors like familiarity (Mak & Jim, 2017; Westover, 1985), satisfaction (Austin et al., 2002; Pain, 1997), experience (Maruthaveeran & van den Bosh, 2015) and attitudes (Hung & Crompton, 2006) has also been examined in the domain of perceived safety and comfort studies. Apart from these factors one of the most sought factors in this domain is the co-presence. Being alone in a space lead to fear in many cases, especially when using public spaces. People always seem more secured with other people in the vicinity (Anderson & Stokes, 1989; A. Jorgensen et al., 2007; L. Jorgensen et al., 2013; Schroeder, 1982; Westover, 1985). This is because people always think that the people in the immediate environment will always help them in case of a danger or a threat (Dogrusoy & Zengel, 2017). But some studies have researched that the perception of safety and comfort differs with the gender of the people recreating (Hung & Crompton, 2006), number of people in the vicinity (Hung & Crompton, 2006; Ratnayake, 2017; Yokohari et al., 2006) and the characteristics and behaviours of the people (Madge, 1997; Mak & Jim, 2017; Özgüner, 2011). Apart from these factors one of the most researched areas in this discipline is the physical factors. Among these also most of the researches covers natural elements while only a limited research seeks the influence from the man-made features (Mahrous et al., 2018; Muderrisoglu & Demir, 2004; Talbot & Kaplan, 1984). Night time lighting and its effects on the perceived safety is also discussed frequently (Anderson & Stokes, 1989; Fisher & May, 2009; Mak & Jim, 2017).

2.1.2 Sense of Safety and comfort with Environmental Factors

The natural elements like vegetation and water features are directly connected to the perceived of safety and comfort of the users as they either create hiding places which are potential for crimes or vast open spaces with no any hiding spaces in case of any threat (Nasar et al., 1993; Nasar & Fisher, 1993). Environmental factors like the topographic variations (Muderrisoglu & Demir, 2004), locations (Özgüner, 2011; Schroeder, 1982) and the surrounding characters has been assessed in many studies.

Similarly, vegetation characteristics and other natural elements either promote visual access or not. Trees obstructing the views can enhance the crime rates (Donovan & Prestemon, 2012) and in the same time high density of vegetation creates hiding places in case of the threats (Dosen & Ostwald, 2013). The more possibility of crimes in urban spaces will construct a sense of danger and threats in the users thereby reducing the sense of safety and comfort. It was also discovered that the view obstructing vegetation like shrubs and small trees has been associated with increased sense of danger (T. R. Herzog & Bryce, 2007; Kuo & Sullivan, 2001) and tall trees are associated with low sense of danger (Nasar & Fisher, 1993). Researches have explored that spaces which allow views and accessibility is perceived as safer compared with the spaces with low level vegetations which obstructs the accessibility (B. Yang et al., 2013). The ability of the vegetation to block or open views is the basic reason of the direct association of the sense of safety with vegetation (Lis et al., 2019a). The spatial characteristics evolved with the different configurations of the vegetation has been the centre of attention in the studies in the domain of sense of safety. Many studies have been focussed on the spatial formations based on the vegetation configurations (A. Jorgensen et al., 2002, 2007; Lis et al., 2014, 2019b; Madge, 1997; Mambretti, 2011; Maruthaveeran & van den Bosh, 2015; Pardela et al., 2022).

2.1.3 Vegetation Configurations and Sense of safety and Comfort

When considering the literature on the vegetation factors and the sense of safety and comfort of the users, two distinct categories can be identified. The first category is where the simple characteristics of the vegetation are assessed with the perceived safety. The types of vegetation (Lis et al., 2019a; Schroeder & Anderson, 1984), placement of trees (Kuo et al., 1998; Mak & Jim, 2017), density of trees (Lis & Iwankowski, 2021; Mahrous et al., 2018), prominence of flowers (Nayanathara & Dharmasena, 2019; Shaffer & Anderson, 1985), presence of trees (Anderson & Stokes, 1989; Lis & Iwankowski, 2021) etc. Apart from this, the second category would be the spatial qualities associated with the vegetation. The level of visibility, enclosure or the openness of spaces (Fisher & Nasar, 1992), legibility, mystery (T. Herzog & Chernick, 2000; Pardela et al., 2022) of the spaces with regards to the vegetation present onsite. Similarly, many studies have been done on the landscape attributes and the sense of safety and comfort.

The direct assessment of sense or the psychological aspects of the safety and comfort in correspondence with the environmental factors are limited. But many studies focus the same scenario in terms of the associated crime rates. It is discovered that the association of crime rates with the vegetation, trees and green spaces are low when compared with non-green spaces in urban areas (Gilstad-Hayden et al., 2015; Troy et al., 2012). Irrespective of the characters and qualities of the vegetation, the mere existence of the greens are said to be associated with the increased perceptions of safety and comfort of urbanites and the users of urban public spaces (B. Jiang et al., 2014; X. Li et al., 2015; Maas et al., 2009).

The researches on the areas of 'tree density' and the perception is frequently carried out as this determines the visual penetration there by influencing the perceived safety (Harvey et al., 2015; Kuo et al., 1998). Similarly the depth of a view in a green environment is also determined by these various characteristics eventually forming safer spaces or dangerous spaces (Chiang et al., 2014; Jansson et al., 2013). A dense vegetation at the low levels forms a solid and non-permeable boundary while a group of trees with high crowns and high trunks form more permeable boundaries (Stamps, 2013). Low level shrubs were considered as possible hiding spaces for assailants this increasing the perception of danger (A. Jorgensen et al., 2007). With different configurations, the views are considered the most important. Similarly, the views towards an individual are also permitted by different vegetation configurations. This factor is also one of the major factors as the 'eyes on the individual' provides a sense of safety and comfort to the considered individual (L. Jorgensen et al., 2013). This concept origins from the Jane Jacobs (1961) 'eyes on street' and the Cohen and Felson's Routine Activity Theory (Mouratidis, 2019).

The most important aspect of the vegetation in terms of the sense of safety is the enclosure created by different vegetation configurations in the urban outdoor spaces. This aspect needs the consideration of ‘three-dimensional space elements’ including the ground plane, vertical plane and the sky plane (Dee, 2001). The vegetation in urban green spaces support the enclosure in all three dimensions and the consideration of this is also an important aspect.

However, the Gestalt Psychology assume that the organisms perceive the visuals as a whole more than sum of its parts, objects or elements. (Behrens, 1998). Thus, the configurations, patterns or combinations are wiser to study rather than individual elements. The similar applies to the visuals within the urban environments as well. The vegetations in the urban environments are perceived as a part of the whole environment. The trees are not seen as separate elements, but they are a part of the natural environment perceived by the users. Similarly, the whole sensible effect of the vegetation is more logical for studying rather than individual elements.

2.2 Theoretical Background

The most important theories involved with the sense of safety and comfort with the physical environment can be identified as Gestalt Theory, Appleton’s Prospect Refuge theory and Stamp’s Permeability theory. Apart from these, Kaplan and Kaplan’s Information processing theory which assess the complex meanings of environmental cues and Attention restoration theory can also be related to the experience of the users with the sense of safety and comfort. All these theories are the assessment of the perceived safety and comfort with the environmental factors.

2.2.1 Gestalt Psychology

Gestalt Psychology emphasize the fact that the human beings perceive the views or environments rather than individual elements or components. This was founded by the Psychologist Max Wertheimer in 1910 while observing some streetlights flashing on a railroad crossing. He observed that the perception of motion on this lights are a mere sequence of flashing lights (Wertheimer & Riezler, 1944). This original idea is nurtured by many other researchers over time. The term ‘Gestalt’ in German translates as, shape or form. This idea of ‘whole is more than sum of its parts’ is strengthen by the Gestalt principles like proximity, figure-ground, closure and connection which emphasizes that the organisms perceive the visuals as a whole rather than separate objects or elements (Sternberg et al., 2012).

2.2.2 Prospect and Refuge Theory

The origin of the Prospect and Refuge theory is based on the Lorenz’s phrase ‘to see without being seen’ and from the Habitat Theory (Appleton, 1975). According to

Appleton's theory, people naturally prefer prospects and refuges where prospect is an unimpeded opportunity to see, and refuge is where there is an opportunity to hide. He goes on to say that when one has the opportunity to observe their surroundings without drawing attention to themselves, that perception is of pleasure rather than fear or perceived danger. (Ramanujam, 2007). Appleton elaborates prospects and refuges are a symbolic interpretation of the combination of different elements in the surrounding. He further claims that there should be a hazard symbol present in the environment for the prospects and refuges to work as intended (Appleton, 1975). This proves the suitability of this theory for the application in safety related studies. The collection of elements in the landscapes will eventually lead for the creation of these basic imageries of prospects and refuges (Appleton, 1984). The arrangement of trees, bushes will create a texture on the surface of a mountain. Similarly trees and vegetation will create different levels of scales and levels of symbolism and escape routes for locomotion with varying arrangements, patterns and configurations (Dosen & Ostwald, 2013). He further extends his discussion to natural elements like clouds, time of the day etc. These aspects has been used as variables in many studies (T. R. Herzog & Kutzli, 2002; Nasar & Fisher, 1993; Nasar & Jones, 1997). With this theory as the basis Nasar et al. (1993) develops a model with the concealment as the cause for perceived danger. According to this study, any physical element like trees, high bushes, walls and buildings which blocks the prospects brings out potentials for being a victim (Blöbaum & Hunecke, 2005). With this it is further elaborated that whenever there is a potential threat, if the space affords escape routes, such a space is perceived as safe by the users (Baran et al., 2018).

2.2.3 Information Processing Theory

This theory is introduced by Stephan and Rachel Kaplan (1989) two distinctive personnels in the discipline of Environmental Psychology in the University of Michigan (Kaymaz, 2012). 2 x 2 matrix was recommended first by S Kaplan (1987) as a predictors of landscape preference. These are called as the 'information variables' (Stamps, 2004). This is accommodated in the recent studies related to sense of safety and comfort as well (T. R. Herzog & Kropscott, 2004; Tang et al., 2015). When determining whether the environment is preferable, people are concerned with two aspects as understanding the environment and predicting and exploring the environment (S. Kaplan, 1987). The four predictors of the perception matrix are coherence (immediate understanding), complexity (immediate exploration), legibility (Inferred understanding) and Mystery (Inferred exploration) (Tang et al., 2015). Coherence is the order, unity, balance and the harmony of an environment which contributes to understand an environment. Complexity is the diversity and the spatial combinations of a space. Both the coherence as well as the complexity focus on the knowledge obtained from the surrounding physical space effortlessly. Legibility is the clarity of the environment to read and find the way back in a particular environment. If the information extracted can be used to build a mental map of the larger environment, then such a space is considered as a legible environment. Mystery encourages an individual to explore more of the environment and learn more related information on the environment. Both legibility and mystery rely on the information extracted from the environment. This depends on the ability to gather information from the environment and imagine and organize the explored information (S. Kaplan, 1987, 1995; Memari & Pazhouhanfar, 2018; Tang et al., 2015).

Table 2.1

Informational variables of Information Processing Theory by Kaplan and Kaplan (1989)

	Understanding	Exploration
Immediate	Coherence Orderly 'hangs together' or a unity, balance, harmony of a scene	Complexity Diversity or the spatial combination of a space
Inferred	Legibility Being clear enough to read and finding one's way there and back	Mystery With the promise to learn more and new but related information

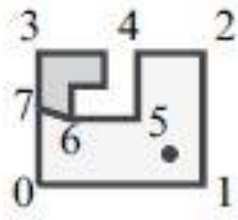
2.2.4 Permeability Theory

Permeability theory by Stamps suggests that the perceived safety and danger is based on the perceptions of enclosure and the spaciousness (Stamps, 2005, 2010a). Stamps narrates permeability theory as 'the enclosure that can be conceived as properties of a three-dimensional region of space which affects safety by the degree to which it permits or limits locomotion or perception through itself' (Stamps, 2005). Accordingly, high concealments or enclosed spaces evokes a sense of danger in the users. With the results from numerous researches, it is discovered that the visual and physical (locomotive) permeability is the most important (Stamps, 2005, 2010b, 2010a, 2011, 2013). Visual permeability is the visual access to the immediate environment without any obstruction and the locomotive permeability is the ability to move whenever there is a perceived threat (Stamps, 2010a). Stamps studies has been based on the spatial enclosure and he argues that the enclosure is directly wedged on the sense of safety of an individual (Stamps, 2005). Stamps (2012) expanded his theory with the exploration of the impacts from the distances to the boundaries to the perceived safety (Baran et al., 2018). Stamps differentiate his theory of permeability with the other famous theories like Appleton's (1975) Prospect Refuge Theory, Gibson's (1979) Theory of Ecological Psychology and Kaplan and Kaplan's (1989) Information Processing theory by noting them as theories based on the verbal constructs for explaining the environments (Stamps, 2005). He presents his theory as a theory based on the geometrical properties of the environments, which is the 'Isovist' of a particular location. Simply, Isovist is the possible set of all the points visible to a given location. In practice, when a light source is placed at the location of the considered individual, the area which is not under the shadow is the Isovist of that particular location (Stamps, 2005). The following variables predict how the Isovist properties can influence the changes in behaviours.

- Horizontal Size – the horizontal area is directly related to the spaciousness of the space. More horizontal area means, there is more room to escape. The distance from the location of the observer to the Isovist boundary has a direct behavioural impact. This distance matters as it determines the time of reaction, range of perception and the opportunity for the escape. The longer the perception range, higher the time for escape.
- Boundary Permeability – the total perimeter of the Isovist can be identified as the boundary permeability. This perimeter can be solid or occluded (regions

Figure 2.1

Point 6.7 in this picture is identified as an occluding chord Source: Stamps (2005)



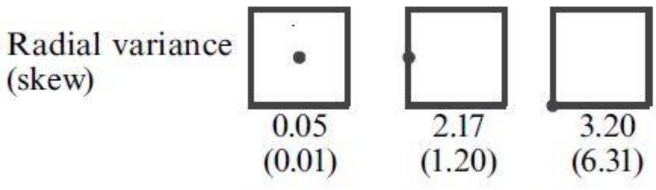
hidden from visual penetration but allows locomotion). Solid boundaries will not allow attacks by unseen enemies while occluded boundaries will permit the locomotion in a threat.

- Variation in distance to the boundary – according to behavioural implications, safety is assured if a person can see a longer range with a close by solid protection in the directions where one is not looking (back or side). The basic principle of prospect-refuge theory is used in developing this attribute. This is often termed as 'radial variance' or 'skew'.

The application of the permeability theory is often seen in the facades, pocket spaces between buildings and interiors (Stamps, 2010a). A similar concept of visual coverage is used in landscape related studies, and it is named as the viewshed. This viewshed deviates slightly from the Isovist as the Isovist characterises the space that can be 'overviewed' or visible to an individual and the viewshed denotes the parts of objects or the elements that are visible. The only consideration in viewshed is the terrain height and vertical viewing angle while the Isovist have no such limit.

Figure 2.2

Radial variance and skew change with the location of an observer (Stamps, 2005)



2.2.5 Attention Restoration Theory

The modern human is under a lot of stress with the daily packed schedules with different wants and needs. This is stress is being enhanced with no environments to restore their fatigues. Many studies have proven that the green natural spaces possess the ability to restore the mental and physical fatigue of the users (Hartig & Staats, 2006b; van den Berg et al., 2003). The rapid constructions specially happening in urban environments have decreased the number of green natural spaces in the urban context (Stigsdotter et al., 2010; van den Berg et al., 2010; T. Yang et al., 2019). This quality of urban greens in restoring the fatigue is explained in the Attention Restoration Theory (Tang et al., 2015). According to Kaplan's Attention Restoration Theory (1995), four characteristics of a space can be used to assess the quality of attention restoration of that space. These are mainly (1) being away (psychological escape from stressful thoughts or physical escape from a stressful town or a similar space), (2) fascination (ability of the environment to capture the attention of the user), (3) extent (perception of the space as a whole, feeling of being engaged in a larger environment), (4) compatibility (the fit between the environmental attributes and the individual's expectations) (K.-T. Han, 2003; S. Kaplan, 1995; Lehto, 2013; Pasini et al., 2014). This attention restoration scale first produced by the Kaplan (1995) has undergone numerous changes over the years as the restorative quality of urban greens has been explored by numerous researchers. This theory mainly associates with the feeling of comfort in the urban green spaces. The essence of this theory is being used by many recent researches which focus on the restoration effect from the green spaces (S. Han et al., 2013; Hartig et al., 1997).

2.2.6 Polyvagal Theory

The Polyvagal theory focuses on the connection between the phylogenetic changes in the autonomic nervous system and social behaviour. Phylogenetic changes show the evolution of a particular species over the time. The autonomic nervous system regulates the involuntary physiologic processes such as the digestion, respiration, blood pressure, heart rate and other processes in the nervous system of a human. This theory is based on the early findings of MacLean where he forwarded three important concepts. First, he elaborated evolution as an arranging aspect which shaped the nervous system and the societal behaviour. Secondly, he validated the biological perspective in the analysis of emotions. Thirdly, he focused on the importance of the role of vagal afferents in regulation of higher brain structures (Porges, 2003, 2009; Winter & Tyree, 2021). This theory provides insights that feelings of safety have a measurable underlying neurophysiological substrate which redirects researchers to investigate the objective perspective of feeling of safety. When humans feel safe their brains support the homeostatic functions of growth, restoration, sociality, productivity, creativity, health and sense of wellbeing. Through these functions an individual becomes accessible to the others without feeling danger or expressing vulnerability. By respecting our need to feel safe, we eventually respect our phylogenetic heritage and provides societal focus on promoting situations to experience sense of safety and co-regulation.

The mentioned theories play a crucial role in identifying the explored literature areas regarding the concepts of sense of safety and comfort. Although there are many other theories which covers the clinical perspective of these concepts, they are not being considered as the main concern of this study is to identify the theories which are also applicable in the urban green spaces.

2.3 Research Gap identified through Literature Review

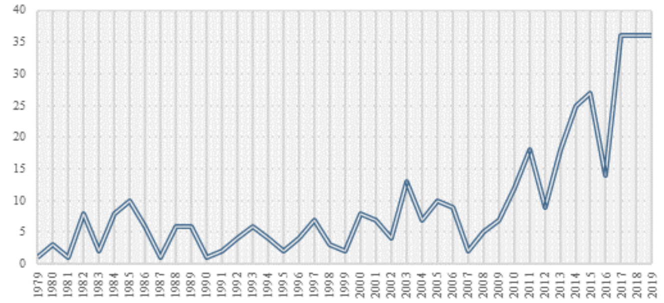
Apart from the general comprehensive research analysis mentioned above, the researcher has conducted a secondary literature analysis which compromises of a technical analysis. This was done through a science mapping approach with the use of the VOSViewer software which is used for constructing and visualizing bibliometric networks (Van Eck & Waltman, 2019).

The first step of the process was conducted with a systematic bibliometric search conducted through the articles obtained through the Scopus database. The literature sources were collected focusing on the sense of safety and comfort and the urban green spaces. These were then screened with digital screening methods and manual screening and the most relevant articles were selected for the next process. The finalized data from the first step were next analysed for a Scientometric analysis through the VOSViewer software following a comprehensive review through manual analysis (L. Kawshalya et al., 2020). The findings of this science mapping approach provided the following results

1. The article distribution by the publication year showed that there is an extreme increase in the number of articles published in the domain of sense of safety and comfort in urban green spaces.

Figure 2.3

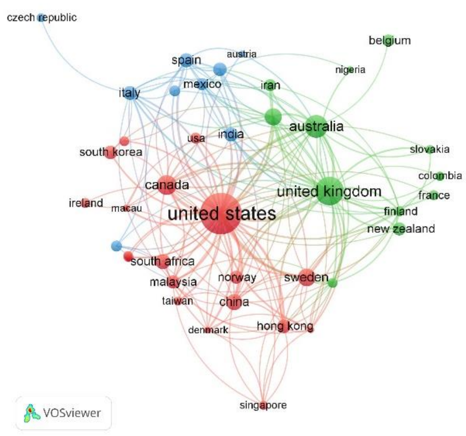
Article Distribution by the publication year (L. Kawshalya et al., 2020).



2. The analysis done on the countries which the articles belong to had revealed that the research on sense of safety and comfort in urban green spaces are more centralized in non-tropical countries like United States, United Kingdom, Austria and Canada etc. This confirmed the fact that there is not enough research done on the tropical climatic countries which elaborated the need of timely research focusing on the similar climatic regions.

Figure 2.4

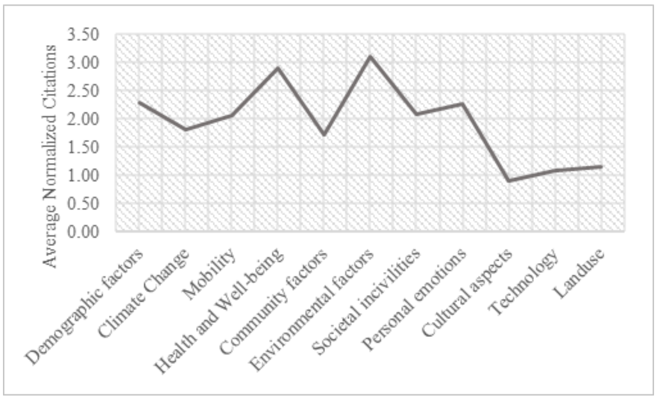
Network visualization of the Journals by VOSViewer software (L. Kawshalya et al., 2020).



3. Keyword analysis of the documents which represents the core content of articles revealed the most recent and highest importance has been on the 'environmental factors'. This shows the importance of exploring the environmental related factors on the sense of safety and comfort in the urban green spaces.

Figure 2.5

Explored Current Research Trends and its impact on the current literature (L. Kawshalya et al., 2020).



Note. Avg. Norm Citation (Average Normalized Citations) - the normalized number of citations of a journal, document, author, or an organization. It equals the total number of citations divided by the average number of citations published in the same year. This value corrects the misinterpretation that the old articles have more time for more citations than the new ones.

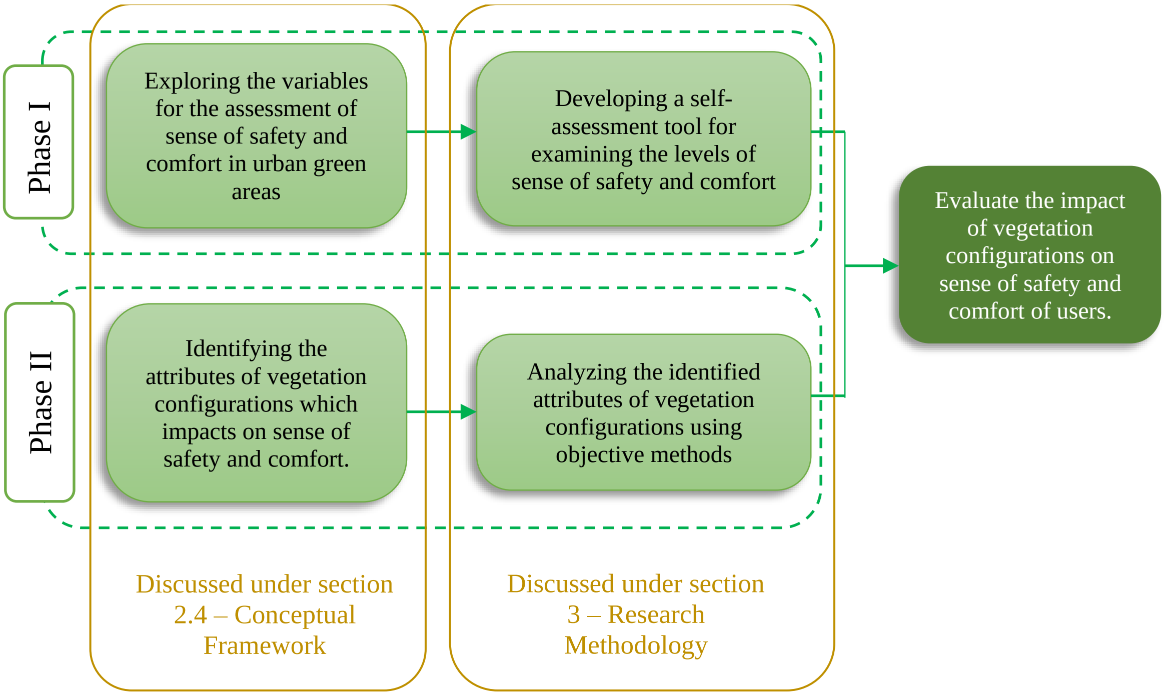
Thus, the researcher has identified the importance of focusing on the environmental related factors on the sense of safety and comfort in urban green spaces in the tropical climates. The literature sources extracted through this systematic bibliometric analysis has provided better insights into the current literature explored.

2.4 Conceptual Framework

According to the research objectives, this research intends to explore two main aspects of exploring how to measure levels of sense of safety and comfort and determining the objective variables related to the vegetation configurations to be assessed.

Figure 2.6

The two main phases of research process



2.4.1 PHASE I – Exploring the variables for assessment of sense of safety and comfort in urban green spaces.

Through the course of literature analysis, some scales were discovered which has utilized the above-mentioned theories for the assessment of the psychological constructs of safety and comfort. The first phase of this study is to create a self-assessment instrument for exploring different levels of sense of safety and comfort in urban green spaces. These scales are considered when selecting the appropriate variables to assess the sense of safety and comfort.

The Sense of safety is discussed comprehensively in the domain of Neuroperception and some relevant scales were also in practice for the assessment of the psychological safety levels. An international team with experience in trauma therapy, Polyvagal Theory, and psychometric scale development led by Dr. Liza Morton at the University of Strathclyde developed the Neuroception of Psychological Safety scale (NPSS). The scale, which measures a person's sense of safety, has 29 items. The items are then separated into three additional subscales: body sensations, compassion, and social engagements. (Morton et al., 2022). Apart from NPSS, the Body perception Questionnaire (BPQ) developed by Chen also focusses on the sense of safety which assess subjective bodily experiences by the people. 122 item scale of 5 subsets, (awareness, stress response, autonomic nervous system, reactivity, stress style and health history inventory) is assessed through a 5 point rating scale (Caballero & Pride, 1984; W.-Y. Chen, 2013). From the five main subsets, section 5; health history inventory is not considered under this research for the obtaining of the variables as the items focus on the health-related complexities. Refer Appendix A for the NPSS and BPQ scales.

For the psychological comfort in the green areas, there have been several studies and theories which can be utilized for the discovery of variables for this study. Hartig et. al. (1997), has developed an scale for measuring psychological factors thought to work in restorative quality in environment, which is also known as Perceived Restoration Scale (PRS) which says that natural views tend to be therapeutic compared to the urban scenes (Hartig et al., 1997). This was developed based on the Attention restoration theory by Kaplan (S. Kaplan, 1995). Exposure to green views significantly reduces the feelings of fear and indict positive effects such as affection and elation are increased. Later with the use of the above scale Han (2003) has developed a Revised Restoration Scale (RRS) which focuses on the stress recovery from mental fatigue from a broader perspective (K.-T. Han, 2003). Both these scales focus on the perceived comfort at open public spaces like parks, square and plazas. Refer Appendix A for the PRS and Revised Restoration Scales.

The above-mentioned scales are used for the development of the self-assessment tool for assessing sense of safety and comfort in urban green spaces. The methods of selecting the variables (section 3.3) and methods of analysis (Section 4.1) will be comprehensively discussed in the later sections.

2.4.2 PHASE II – Identifying the attributes of vegetation configurations which impacts on sense of safety and comfort.

The phase II of the study concerns analysing the attributes of vegetation configurations using objective methods. With the literature analysis, the author has mentioned that the qualities of vegetation configurations are either looked into with single elements or as a quality of the space. With the pragmatic approach for the study, the researcher selected overall qualities of the spaces which are a result of different arrangements of the vegetation as these qualities are directly perceived by the users of the space.

In many research studies visual qualities of the open spaces are assessed as the human perceive primarily through eyes. The openness and the enclosure of the spaces (Hashim et al., 2016; Maas et al., 2009; Nasar, 1982), prospects (Fisher & Nasar, 1992; Ratnayake, 2017; van Rijswijk & Haans, 2018), view distance (Mahrous et al., 2018; Muderrisoglu & Demir, 2004; Yokohari et al., 2006) has been studied in previous studies extensively. The recent research has focussed on the spatial structures like height to width ratio of the space (Aung, 2020). The most recent research has taken this visual assessment to the next level by using latest technologies like the use of machine learning and AI in analysis (Klemm et al., 2015; Qiu et al., 2021; Schirpke et al., 2022). These shows how the visual analysis in open spaces has been evolved with the advancements in the technology. Apart from the visual analysis, physical attributes like the accessibility (M. Andrews & Gatersleben, 2010; Mak & Jim, 2017), escape routes (Fisher & Nasar, 1992), boundary demarcations (Morgan et al., 2018; Muderrisoglu & Demir, 2004) of the spaces has also been focussed heavily in the research studies. Thus, consideration of the physical character which is a result of different arrangement patterns of the vegetation should also be considered for this study. Considering all these the author has selected the attributes which covers the visual qualities and physical qualities of a space which is a result of different arrangements and configurations of the vegetation (Behrens, 1998; Bustamante, 2022; O'Connor, 2013). Additionally, the author has tried to use traditional methods to latest methods which use latest technologies for a comprehensive, timely and practical study. Thus, the following attributes were selected for the analysis as the attributes of vegetation configurations which impacts on the sense of safety and comfort of the users.

Table 2.2

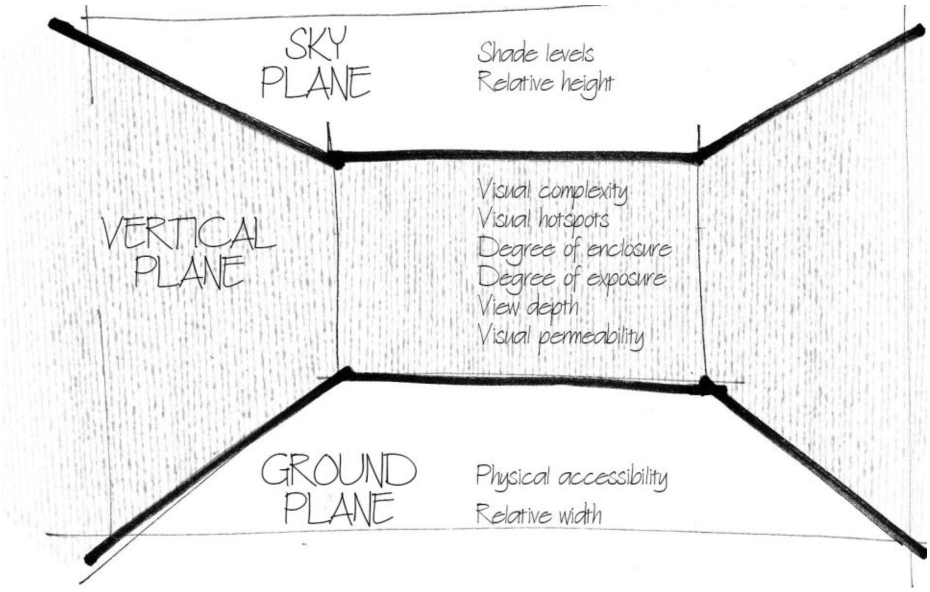
The attributes selected and the respective sources of citation.

Attribute	Sources
Visual Complexity	(L. W. G. Kawshalya et al., 2022; Lu & Tang, 2004; Shen, 2002)
Visual hotspots	(Schirpke et al., 2022)
Shade levels	(Caldera & Perera, 2018; Klemm et al., 2015; Talbot & Kaplan, 1984)
Degree of enclosure	(Donovan & Prestemon, 2012; Dosen & Ostwald, 2013; Lis et al., 2019a)
Degree of exposure	(Baran et al., 2018; Burgess et al., 1988; L. Kawshalya & Dharmasena, 2019; Wekerle, 2000)
Relative Scale	(Aung, 2020; Kim, 2017; Kim & Kim, 2019)
View Depth	(Batty, 2001; Chiang et al., 2014; Foltête et al., 2020; Schirpke et al., 2022)
Visual permeability	(Baran et al., 2018; Mehta, 2014; Stamps, 2005, 2010b, 2013)
Physical accessibility	(Carmona, 2021; Lopes et al., 2019; Mak & Jim, 2017; Mehta, 2014; B. Yang et al., 2013)

The above-mentioned attributes are selected considering the three-dimensional space elements as forwarded by Dee (2001). The following diagram shows how the above selected attributes are categorized under the ground plane, vertical plane, and sky plane. It is to be noted that relative scale is calculated based on the relative height and width of the selected space.

Figure 2.7

The selected attributes relevant to the sky plane, vertical plane and ground plane



Different techniques like onsite characteristic analysis and stimuli analysis will be conducted in the data collection process. These will be comprehensively discussed under section 3.4.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Philosophy

For better understanding of the research philosophy used, first the structure and the agency of assumptions should be identified. Epistemology assumption refers to the knowledge, what is considered as the valid and legitimate knowledge (obtained from visual, textual data, numerical data, opinions including stories and narratives) and how to communicate this knowledge to the others (Saunders et al., 2019). Similarly, this research focuses on the numerical and textual data about the vegetation configurations in urban green spaces thus, the epistemological assumption is applied here. As this research contributes to making a difference in the practice of designing spaces in urban environments, the philosophy of 'Pragmatism' is focussed here. Pragmatism argues that the concepts or theories are relevant only when they are applied in the practice (Kelemen & Rumens, 2008). For Pragmatists, the practical applications of the explored knowledge and the reality of enabling actions matters. From the research problem, the pragmatists explore the solutions which can be enabled in the practical environment in the future practices (Saunders et al., 2019). This study used an abductive approach to theory development, where the framework's construction and the conclusions demonstrate the flow from theory to data (induction) and data to theory (deduction) (Suddaby, 2006). In this approach of abduction, first data collection is used to discover a phenomenon and recognize patterns within. And then the explored patterns are compiled in a conceptual framework and this is tested through a data collection again which is called the validation process. The modification of the existing theories and building up new theories where appropriate is done through this approach (Saunders et al., 2019).

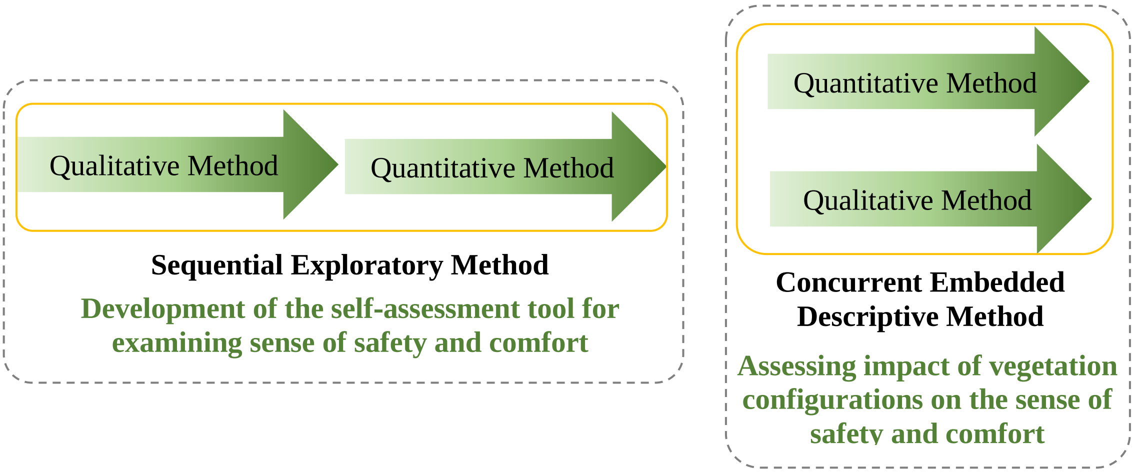
3.2 Research Design

3.2.1 Methodological Choice

This study employs a mixed method approach, utilizing both qualitative and quantitative methodologies. Mixed method approaches have a more pluralistic view of research methodology incorporated (Saunders et al., 2019). This study follows a multi-phase research design process with an exploratory study following a descriptive phase. The process of development of the self-assessment tool for assessment of safety and comfort follows a sequential exploratory study. The qualitative data will be obtained and after refining the final list, quantitative data is obtained for factor analysis. The second stage of impact analysis of the vegetation configurations on sense of safety and comfort process follows a concurrent embedded descriptive study. Here embedded data will be obtained with both quantitative and qualitative data concurrently. The qualitative data obtained in this stage will provide the necessary explanations of certain behaviours of data set (Saunders et al., 2019).

Figure 3.1

Multi-phase research methodology incorporated into the study

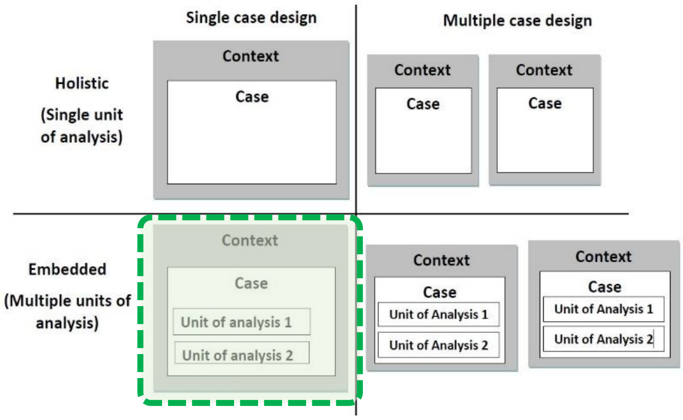


3.2.2 Research Strategy

The two phases of the study employ two different research strategies. The initial phase of the development of self-assessment tool is conducted with a survey while the final phase is conducted through a case study. The survey strategy (used for understanding a whole population through focusing on a selected sample) is used in this study for deductive research approaches. The surveys are frequently used in exploratory and descriptive research. Using questionnaires for survey is popular as it permits collection of standardized data (as questions) from a large number of respondents economically, allowing easy comparison through the data (Saunders et al., 2019). The research strategy accompanied in the second phase of the study is 'Case Study'. A case study is an in-detailed inquiry on a focussed topic or phenomenon within its real life setting (no staged or mock settings) yielding more empirical descriptions and rich findings relative to real life settings (Dubois & Gadde, 2002; Yin, 2018). This study accompanies case studies to test the impact from the vegetation configurations on the sense of safety and comfort. Embedded multiple units of analysis of a single case design will be used in this study where the unit of analysis will be the spaces which are frequently used by the users for relaxing.

Figure 3.2

Case study categorization, (Yin 2018)

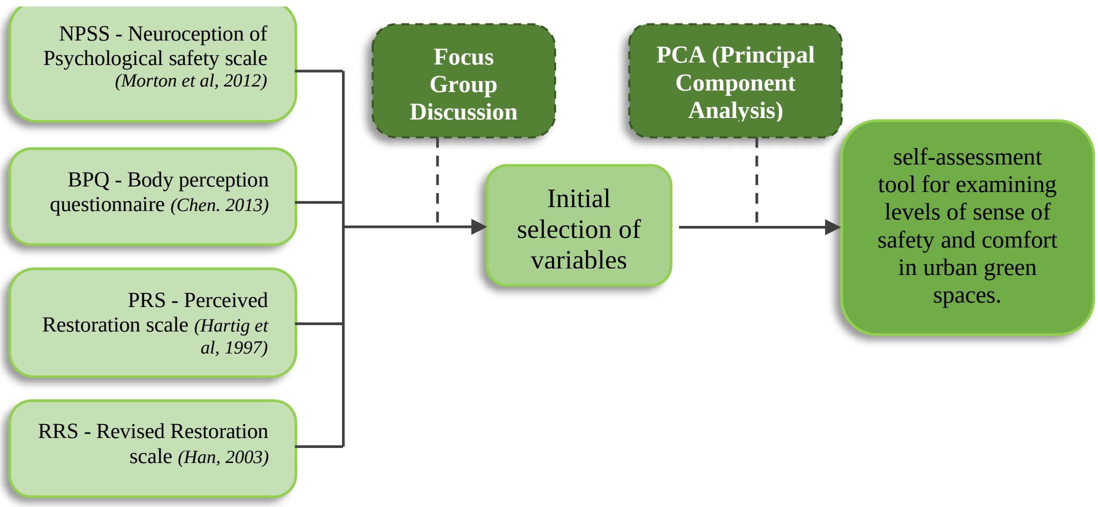


3.3 Techniques and Procedures of Data Collection – PHASE I

For the first phase of developing a self-assessment tool for examining the levels of sense of safety and comfort in urban green spaces. Out of the variables (Self assessing statements) in the selected scales (under section 2.4.1) a set of variables is to be selected first, and those variables are to be assessed for the data reduction and summarization and finally obtain a set of variables which are considered to be the best for the assessment of sense of safety and comfort in urban green spaces. The initial selection of the variables is to be done through a focused group discussion. The final selection and summarization of the variables are done through a Principal Component Analysis (PCA). The finalized set of variables through PCA will be the developed self-assessment tool for examining levels of sense of safety and comfort in urban green spaces.

Figure 3.3

Process of development of the self-assessment tool for examining levels of sense of safety and comfort in urban green spaces



3.3.1 Focus Group Discussion

The focus group discussion to sort out the variables from the selected assessment scales are done through the participation of 6 experts in the fields of perception-based studies through an online platform (zoom). The variables were selected through a thorough screening process. The consideration for the selection is the applicability of the phrases in the urban green spaces of Sri Lanka (tropical climate) for the assessment of the psychological constructs of safety and comfort. Thus, the final selected variables are as follows.

Table 3.1

Selected variables after the focus group discussion.

V1	I feel elated looking at the surrounding	**Assessment of Perceived Comfort**
V2	I feel relaxed looking at the surrounding	
V3	I feel concentrated in this space	
V4	It's calm and quiet (comparatively) here	
V5	I feel attentive to my surrounding	
V6	I prefer what I see here	
V7	I am interested in the scenes from this space	
V8	I would like to stay here longer	
V9	I would visit this place again	
V10	The scenery has fascinating qualities	
V11	I enjoy being here	
V12	I feel energetic being in this place	
V13	I feel pleasant spending time here	
V14	I feel cheerful looking at the sceneries	
V15	What I see here is more attractive	
V16	I feel connected with this space	
V17	I am satisfied with what I see in this space	
V18	I can freely enjoy myself here	
V19	I forget all the problems when I am here	
V20	My mental fatigue keeps decreasing when I am here	
V21	I feel refreshing to be here despite the thermal conditions	
V22	I would love to explore and discover more in this space	**Assessment of Sense of Safety**
V23	My eyes are not tired at all	
V24	My breathing is effortless in this space	
V25	My heart rate is steady	
V26	I feel confident to do what I like here	
V27	I feel comfortable expressing myself in this space	

V28	I feel like people in this space would try their best to help me
V29	I feel accepted by other users
V30	I don't feel intimidated by the other users
V31	I didn’t feel judged by others
V32	My body felt relaxed
V33	I feel there are no threats in the surrounding
V34	I feel harmless in this space

3.3.2 Principal Component Analysis (PCA)

The responds to the above 34 variables were collected through an online expert survey. Experts from the disciplines of architecture, landscape architecture, urban planning, town planning, perception based, and behaviour-based research fields with more than 3 years of experience were asked to take part in this exercise. Using the snowball sampling technique, the respondents were chosen. In order to gauge the level of comfort and safety in urban green spaces, the experts were asked to rank the significance of the aforementioned phrases. The questionnaire explanation clearly mentioned the difference between the psychological constructs of safety and comfort and the expected field assessment of the urban green areas. A 7 – point rating scale was used for the exercise (1 – Not at all important, 7 – Extremely important). A considerably high rating scale (7-point) was used as the targeted sample is informed and familiar about the aspects concerned in the questionnaires and they have a high range of judgment where they can compare and provide a more insightful answer for each response (L. W. G. Kawshalya et al., 2022). A total of 174 responses were collected in the course of more than 3 months. The responses collected were then analysed accordingly.

The finalized set of variables are to be used in assessing the sense of safety and comfort in urban green spaces (units of analysis) selected for the study. This is done through the development of an equation based on the outcome results of the PCA. Thus, the outcome of PCA is like the base of the phase I of developing a self-assessment tool.

3.4 Techniques and Procedures of Data Collection – PHASE II

The phase II of the study is to analyse the identified attributes of vegetation configuration and decide on relevant objective methods. Each attribute is thoroughly studied, and suitable objective methods are selected. Based on the method of analysis, two main categories of can be identified as

1. Stimuli based analysis.

2. Physical space analysis

The next section of this chapter discusses the selected objective methods of analysis for each of the selected spaces in the case study.

3.4.1 Stimuli based Analysis.

This study uses two different types of stimuli for the analysis of visual complexity, visual hotspots and shade levels. Panoramic landscape photographs (PLP) are used for the visual hotspots and visual complexity analysis while digital hemispherical photographs (DHP) are used for the analysis of plant area index (PAI) levels and sky visibility.

3.4.1.1 Visual Complexity

Complexity, according to Kaplan and Kaplan, is one of the elements that gathers data from the surrounding environment for in-depth investigation of that specific space. (R. Kaplan & Kaplan, 1989). Complexity is defined as a space's richness, diversity, and arrangement of various colours, forms, and patterns in the physical objects and features that are there. (Ode et al., 2010). Berlyn (1974) states that human by nature is satisfied with medium levels of complexity (Berlyne, 1974). Similarly Rapoprt states that too little levels of complexity can create sensory distress creating chaotic feelings while too much complexity can create sensory overload (Ewing & Handy, 2009; L. W. G. Kawshalya et al., 2022).

Visual complexity is measured with different scales and measurement methods. Some of these would be entropy calculations (Stamps, 2003), Shannon Diversity Index, Simpson's Diversity Index (Spellerberg & Fedor, 2003) and Fractal Dimension (S. Jiang & Liu, 2012; Shen, 2002). These diversity indices are calculated using pixel recognition software which detects the vegetation, sky and other elements in PLPs. This technology is still in the development stages in the context of study and the accuracy of the available methods have shown limitations in the practical context (L. W. G. Kawshalya et al., 2022)

In this study, the objective measure of complexity is the fractal dimension considering the access to the methodology and the proved efficiency of this method. There are many other objective measures of complexity which focus on indexes like Shannon diversity index, Simpson index and entropy etc. But fractal dimension is particularly selected in this study as it suits more in an environment with natural shape defining points rather than focusing on the elements and species present in the environment. Fractal dimension focus more on the visual aspects of the perception with compared to the other objective methods of the complexity.

The Latin terms "frangere" and "fractus," which mean fragmentes and denote irregularity and roughness, are the source of the term "fractal" (B. Mandelbrot, 1967; B. B. Mandelbrot, 1982). A helpful landscape metric for examining the complexity and irregularity of patterns in landscapes is the fractal dimension (Imre & Bogaert, 2004). Although this fractal dimension is primarily used for identifying the patterns across landscapes, it has shown great potential in analysing the visual sceneries for the visual complexity (L. W. G. Kawshalya et al., 2022). The recent development of studies with the fractal dimension in the urban context has proven its worth in the domain. The area-radius method, the box counting method, and the perimeter-area related method are the three basic techniques used in fractal analysis of urban form. (Lu & Tang, 2004; Shen, 2002). Due to its ease of use and efficiency in terms of linearity, areas, and volumes, the box counting method is widely used in perception-based urban studies that concentrate on visual parameter analysis. (S. Jiang & Liu, 2012)

The fractal dimension evaluates the level of detail in a scene's fractal pattern. For the purpose of analysis in this study, the landscapes are photographed as panoramic landscape photographs (PLPs). For the purposes of analysis, each PLP is regarded as an entire urban patch. The fractal dimension coefficient (D_b) is extracted by means of the box counting technique.

When a PLP is first inserted, it is first covered by a single box (1×1) that contains the entire PLP (the captured scenery). The side lengths of the box r_1, and the basic grid, L, are equal in this first step. Next, the number of boxes that the N_1 urban patch occupies is counted. $N_1 = 1$ in this case. The grid is divided by (2×2) in the second step, and the PLP is covered by a total of 4 boxes. In the second example, the box's side length is $r_2 = L/2$. N_2 is the number of boxes that the urban patch occupies. The number of boxes is noted as N_n., and this process is repeated *n* times. With every step, the box size r will decrease. Lastly, the total area $N_n r_n^2$ that the urban patch occupies within the boxes is computed. The following is an estimate of the box counting fractal dimension. (S. Jiang & Liu, 2012).

$$D_b = \lim_{r_n \to \infty} \frac{log\ N_n}{log\ (\frac{1}{r_n})}$$

In practical application, log N_n and log $(1/r_n)$ are plotted in a scatter plot, and the D_b for the considered image is determined by taking the slope of the best fit curve. This is how it is estimated (S. Jiang & Liu, 2012).

$$\ln N\ (r) + D_b \ln\left(\frac{1}{r}\right) + b_1 = 0$$

The ImageJ program, which was first created by Wayne Rasband in the United States in 1997, was supported by the study in order to analyse the PLPs. This free program

ImageJ computes a number of statistics about the pixels in images (Karperien, 2007). The analysis is conducted using the Fraclac plugin (Author A Karperien 2007, Australia), which was created specifically for the analysis of the fractal dimension using the box counting method D_b. Figure 4.4 represents the outputs from the software. This study will utilize the acronym (D_{fract}) for fractal dimension coefficients.

Figure 3.4

Fractal dimension analysis (1) Binary image processed through image J software (2) box counting image presentation, Fraclac plugin (3) best fit line with the scatterplot, Fraclac plugin.

3.4.1.2 Visual Hotspots

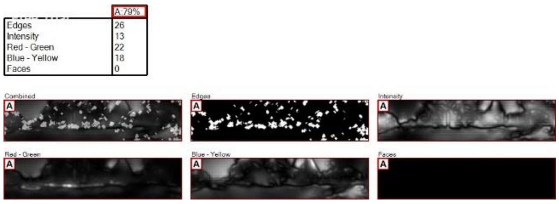
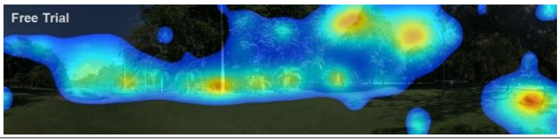
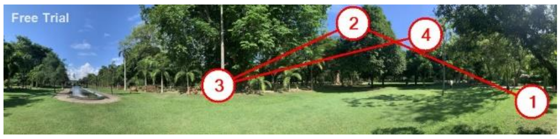
To comprehensively understand the landscape characteristics of the space, panoramic photographs are used for a detailed analysis (Foltête et al., 2020). Eye tracking experiments objectively measure which parts are focused when people view sceneries and how long and in which sequence they look at different objects (De Lucio et al., 1996; Y. Liu et al., 2019). However, for a very long time, many disciplines that emphasize visual aspects—such as marketing, geography, cartography, psychology, and landscape planning—have routinely used these eye tracking experiments. (De Lucio et al., 1996; Müller et al., 2012; Ode Sang et al., 2016). But recently these techniques are frequently used in landscape perception research. With the use of these techniques the relationship between perception with level of openness (Dupont et al., 2014), visual complexity (Dupont et al., 2017), beauty(Y. Liu et al., 2019) and visual preferences in urban green spaces are being investigated (Q. Liu et al., 2021). It can be stated that the eye tracking technique is a better approach in the setting of landscape perception with no linguistic barriers (Cottet et al., 2018). Hollander et al. assessed the connection between the products of laboratory-based experiments and simulation software generated results of urban design perception research. The results predicted that the laboratory based eye tracking results can be substituted by the simulation software results (Hollander et al., 2020). Many studies focusing on the urban settings and streetscape facades have learned promising results based on this discovery (Hollander et al., 2021; Lavdas et al., 2021; Salingaros & Sussman, 2020).

These investigations have been conducted in conjunction with 3M's Visual Attention Software (3M-VAS), a proprietary artificial intelligence (AI) program that evaluates a person's "first glimpse vision." Information about the pre-attentive processing of the visual elements is provided by this software. (Lavdas et al., 2021). Starting at the retina, a photoreceptor array, the process analyses low-level visual features before moving on to the thalamus and early visual cortical areas. (Gabbiani & Cox, 2017; Vlasiuk & Asari, 2021). Neurons at the initial perception process react top simple visual properties like colour opponency, intensity contrast, orientation, direction and velocity of motion etc. (Itti & Koch, 2001). The information extracted in the process of pre-attentive process which generally lasts for about 200 ms – 250 ms, is used for guiding the next step of selective attention (Wolfe, 2021).

Similar to the approaches mentioned above, this study also accommodates 3M-VAS software to analyze the hotspots in the captured PLPs. Experts in neurology and data sciences created the 3M VAS software to quickly and precisely mimic how viewers will perceive your images within the first three to five seconds. Utilize human-vision AI while working with 3M-VAS. With 92% accuracy, VAS makes instantaneous predictions about what viewers will see at first glance. The subsequent results (as shown in Figure 4.5) will be provided by the software after the analysis,

Figure 3.5

The outputs produced by the 3M VAS software

Areas of Interest	Provides probability scores on the likelihood specified areas of interest will be seen within the design	
Visual Elements	Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.	
Heatmap	Provides an easy-to-read visual overview of the salient areas of the design.	
Hotspots	Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.	
Gaze Sequence	Presents the order a person will view the first 4 areas most likely to be noticed.	

The PLPs used for the exercise is of same size (16382×3868 Pixel) and resolution (72 dpi) which will not create any complications in the process of analysing (comparisons).

The PLPs are analysed with the 3M-VAS and the following characteristics were analysed. Here some characteristics directly generated by the software and some other secondary data are analysed. (Schirpke et al., 2022)

Table 3.2

The attributes analysed through the outputs produced by the software 3M-VAS (Schirpke et al., 2018)

	Unit	Acronym	Description
Number of hotspots	n	HP	The quantity of hotspots in the image
Hotspot area	%	HP_{area}	The hotspots' total estimated area in the PLP
Mean hotspot probability	%	HP_{mean}	Average chance of first examining the hotspots, average for all hotspots
Area-weighted mean hotspot probability	%	HP_{mean_w}	Mean of all hotspots and area-weighted mean probability of initial eye-tracking movement
Highest hotspot probability	%	HP_{max}	Probability of the hotspot with the highest probability (top-hotspot) moving initially when eye-tracking
Lowest hotspot probability	%	HP_{min}	Probability of the hotspot with the lowest probability making an initial eye-tracking movement
Top-hotspot area	%	HP_{max_area}	Area of the top hotspot estimated
Edges of visual elements	%	VE_{edges}	The calculated average contribution of the visual element edges within the hotspots to the total likelihood
Intensity of visual elements	%	$VE_{intensity}$	The calculated average contribution of the visual elements' intensity within the hotspots to the total probability
Red-green colour contrast	%	$CLR_{red\text{-}green}$	Red-green colour contrast of visual elements within the hotspots' estimated mean contribution to the overall probability
Blue-yellow colour contrast	%	$CLR_{blue\text{-}yellow}$	The visual elements within the hotspots' estimated mean contribution of the blue-yellow colour contrast to the overall probability
Proportion of vegetation captured in the hotspots	%	HP_{veg}	Proportion of greens captured in the Hotspots identified through the eye tracking simulation software.

Apart from these the overall proportion of greens captured through each PLP is recorded to obtain an idea about the levels of greens in the captured visual frames from the selected spaces in the case study area.

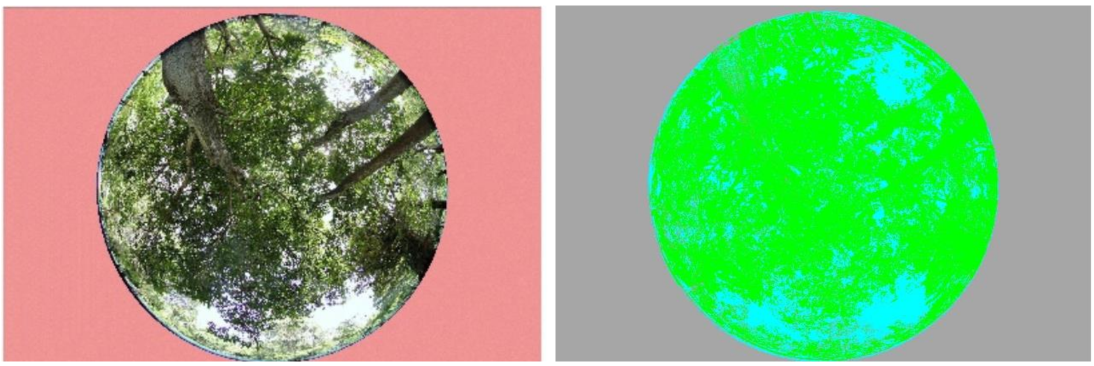
3.4.1.3 Shade levels

The primary factor which determines the shade in a green space is the tree canopy coverage of trees. Many studies carried out in search of thermal comfort with the vegetation has considered the leaf area index (LAI) as the quantification of the shade provided by trees (Song et al., 2018; Xiao et al., 2018). Higher LAI is associated with high cooling effects in urban areas thus, high LAIs were preferred by the urban users (Xiao et al., 2018). The direct measurement of LAI through litter falls or destructive sampling is considered to be more expensive and time consuming. The indirect methods are easy to handle and assess but the answer is actually a Plant Area Index (PAI) rather than a leaf area Index. This is because the indirect method considers the stems, tree trunk, branches as leaves (Zhao et al., 2012). But this study focusses mainly on the visual aspect of shade, thus the PAI is adequate. Since the vegetation configurations are in question of this study, the Plant Areas which impacts on the shade is considered.

Digital Hemispherical Photographs - DHPs (taken at approximately 1.5m high mounted on a stand) are used for the calculation of the PAI. Digital photographs of the selected unit of analysis (spaces used for resting in urban greens) are taken and the PAI s are calculated using the software CAN_EYE V6.495 (Y. Zhang et al., 2005). From the outputs produced through the software, the percentage of the sky coverage (DHP_{sky}) and the vegetation coverage (DHP_{veg}) is to be taken for the analysis. The visibility of the sky provides sense of openness, and this is important in preference and positive emotions. These feelings directly correlates with the psychological comfort of the users (Caldera & Perera, 2018). Thus, it is important to assess this factor under this study. The camera model used for capturing these DHPs is Canon EF 8-15 mm f/4L Fisheye USM lens. The image size (3360×5040 pixels) of the input DHPs, height to width ratio (1.2×1.6) and the focal length is similar and will not impact in the comparison analysis.

Figure 3.6

(1) Processed DHP images and mask (2) classification results of the final output DHP images.



3.4.2 Physical Space Analysis.

The rest of the selected attributes are analysed through physical space analysis. This is done through physically measuring the space and mapping the space as it is on site visits. The selected spaces on the case study area are mapped according to the elements and features onsite. Secondly all the mapped data are transferred into a technical drawing with the use of AutoCAD and analysed accordingly. The methods of calculations are discussed in the following sections.

The major challenge in this step was to determine the appropriate measurement methods for the selected attributes which would reflect the exact conditions perceived by the users of the space. Baran et al, (2018) states that a 15m radius area from a standing point adequately reflects the sense of enclosure. To calculate the level of enclosure, the obstacles and prospects in the 15 m radius circle at the eye level (approximately 1.5m height from the ground level) are considered (Baran et al., 2018). The 360^0 Isovist radiating from the centre of the selected location is taken into the calculation. The visible angle and the angle of obstructions are marked as a percentage of the 360 degrees view of an individual in the centre of the selected location (observation point) for the determination of the degree of enclosure of a particular space. A similar approach is used for the determination of the degree of exposure. This degree of exposure determines how much the standing point of a space is visible to the other users in the surrounding spaces of the park beyond the 15m radius circle. Related to the calculation of the degree of exposure, here also the angle of visibility from the outer spaces are taken into account as a percentage of the 360-degree view. Both these degrees of enclosure and degree of exposure are considered at the average eye level of an individual.

Using a similar approach but considering the ground level objects for movements are considered in determining the level of physical accessibility. Whether the elements in the ground level allows free and easy movements or not. The presence of low-level shrubs and plants which limit movements, overgrown roots of the trees and uneven ground (creating unsafe situations) are considered in determining the physical accessibility level of a selected space.

All three of the above attributes (degree of enclosure, degree of exposure and physical accessibility) are determined by the elements in the 15m radius of the spaces selected. The researcher roughly sketched the present location of the trees and other elements in the vicinity (15m radius). A rough determination of the angles of the location of the different elements is roughly estimated through a mobile application which allows the measurement of angles from a particular location. With these estimated angles the conditions under which the space is enclosed, exposed or physically accessible are marked in a map physically on the site premises.

The researcher's first-hand experience largely determines the degree of permeability of space. The level of visibility of the elements within and beyond the 15m radius is considered here. Whether the visual pathway for these elements is fully open, hindered by the vegetation or fully blocked is determined by the experience of the researcher. Whether the obstructing elements falls within the range of 15m is determined using a laser range finder distance meter (PCE-LRF 500). The closest element in the visibility is chosen and the distance is measured by the instrument. Whether the element is closer than 15m or not is then marked on the sketch. Then all the elements which fall within the range of is considered and their respective permeability is marked simultaneously.

Relative scale of a space is calculated with the measurements of relative height and relative horizontal distance for the nearest significant element. The height to width ratio is taken as the relative scale. The average and perceived height to the understorey of the trees around the space is taken as the relative height and the distance to the most prominent element in the space is taken as the relative horizontal distance.

The view depth of a space is also determined using the laser range finder distance meter. The depth of the visibility is determined through the longest visual distance from the observing point. Depending on the distance, three types of categories such as low, medium, and high are used for the analysis in this study. Please see table 3.3 for more comprehensive understanding of the measurements of the selected attributes and calculations.

Table 3.3
The methods of measurements for the selected attributes under physical space analysis

Attribute (Acronym)	Considerations	Measured from	Measured at	Conditions of measurement
Degree of enclosure (D_ENCL)	Visual obstacles in the 15m radius from the observing point – which completely obstructs views beyond 15m.	Observing point – 360^{0} Isovist of visibility	At the average height of a human – 1.5m above the ground level	If the visibility of the elements beyond 15m radius is fully obstructed as a result of an element within 15m radius, then such angle of vision is considered as enclosed. If the visibility of elements beyond 15m radius is clearly visible, then such angle of vision is considered as open. $\begin{pmatrix} Degree\ of \\ Enclosure \end{pmatrix} = \frac{Angle\ of\ vision\ enclosed}{360} \times 100$
Degree of exposure (D_EXP)	Visibility of the observing point from the circumference of 15m radius circle	Circumference of the 15m radius circle from observing point	At 1.5m above the ground level	Only the spaces frequently used by the users in the 15m circumference is considered. i.e.: - the researchers just observed the observing point in a 15m circumference and the sections of arcs where observing point is clearly visible is marked (but the calculation will be done based on the arc angles). The researchers did not specially go into spaces which are not used by normal users to check the visibility of the observing point. Presence of pathways and designated resting spaces in the circumference and the visibility from such spaces is considered as possible spaces of exposure. $\begin{pmatrix} Degree\ of \\ Exposure \end{pmatrix} = \frac{Angle\ of\ exposure}{360} \times 100$
Relative scale (R_SCL)	Relative height to the	Observing point	Height above the	The average height or the perceived height to the understorey of the trees is considered. If there are no understorey directly on the observing point, then the other surrounding elements are considered to determine the height. But this is

	understorey of the trees		ground level	only when these surrounding elements directly depict an impact of the perception of the users. An approximate height is determined by the researcher along with the average height of a human.
	Relative horizontal distance	Observing point	At the ground level	When the individuals are in a space, the horizontal distance to the closest and the most prominent object is selected as the horizontal distance for the calculation. $(Relative\ Scale) = \frac{Relative\ height}{Relative\ horizontal\ distance}$
View depth (V_DEP)	Depth of the visibility	Observing point – 360^0 Isovist of visibility	At 1.5m above the ground level	The distance to the farthest elements seen from the observing point should be considered. If the farthest distance is more than 120m, then it is considered as high view depth. If the farthest distance visible is between 120m - 60m then it is considered as medium view depth. If it is less than 60m it is considered as low view depth (these numbers are based on zone classifications by Schirpke et al., (2022) and the pilot data collection). More than 20% of the view shed coverage should be in the above ranges to call it as high, medium or low.
Visual permeability (V_PRM)	How clear the vision is at a 15m radius	Observing point – 360^0 Isovist of visibility	At the average height of a human – 1.5m above the ground level	If the 15m radius is clear with no elements hindering the visibility, then such angle of vision is considered full open. If nothing is visible, and vision is obstructed by an element, then such angles are considered closed. If the vision is permeable through the vegetation and not enclosed, then such areas are considered as permeable. The open angle of vision is considered as 1, permeable angles are considered as 0.5 and closed angles are 0 for the final calculation of the level of permeability.

				$\begin{pmatrix} Visual \\ Permeability \end{pmatrix} = \frac{\left\{\begin{pmatrix} Open\ angle \\ of\ vision \end{pmatrix} \times 1\right) + \begin{pmatrix} Permeable\ angle \\ of\ vision \end{pmatrix} \times 0.5\right) + \begin{pmatrix} Closed\ angle \\ of\ vision \end{pmatrix} \times 0\right)\right\}}{360} \times 100$
Physical accessibility (P_ACS)	Physical obstacles in the 15m radius from the observing point	Observing point – mobility to all the directions	At the ground level	Only the spaces which are freely accessible from the observing point is considered. The restrictions of the movements from the observing point are considered. The low-level bushes or plants, physical obstructions (manmade features) and even the overgrown root of the space is considered as elements which restricts the movement. $\begin{pmatrix} Level\ of\ physical \\ accessibility \end{pmatrix} = \frac{Angle\ of\ free\ movement}{360} \times 100$

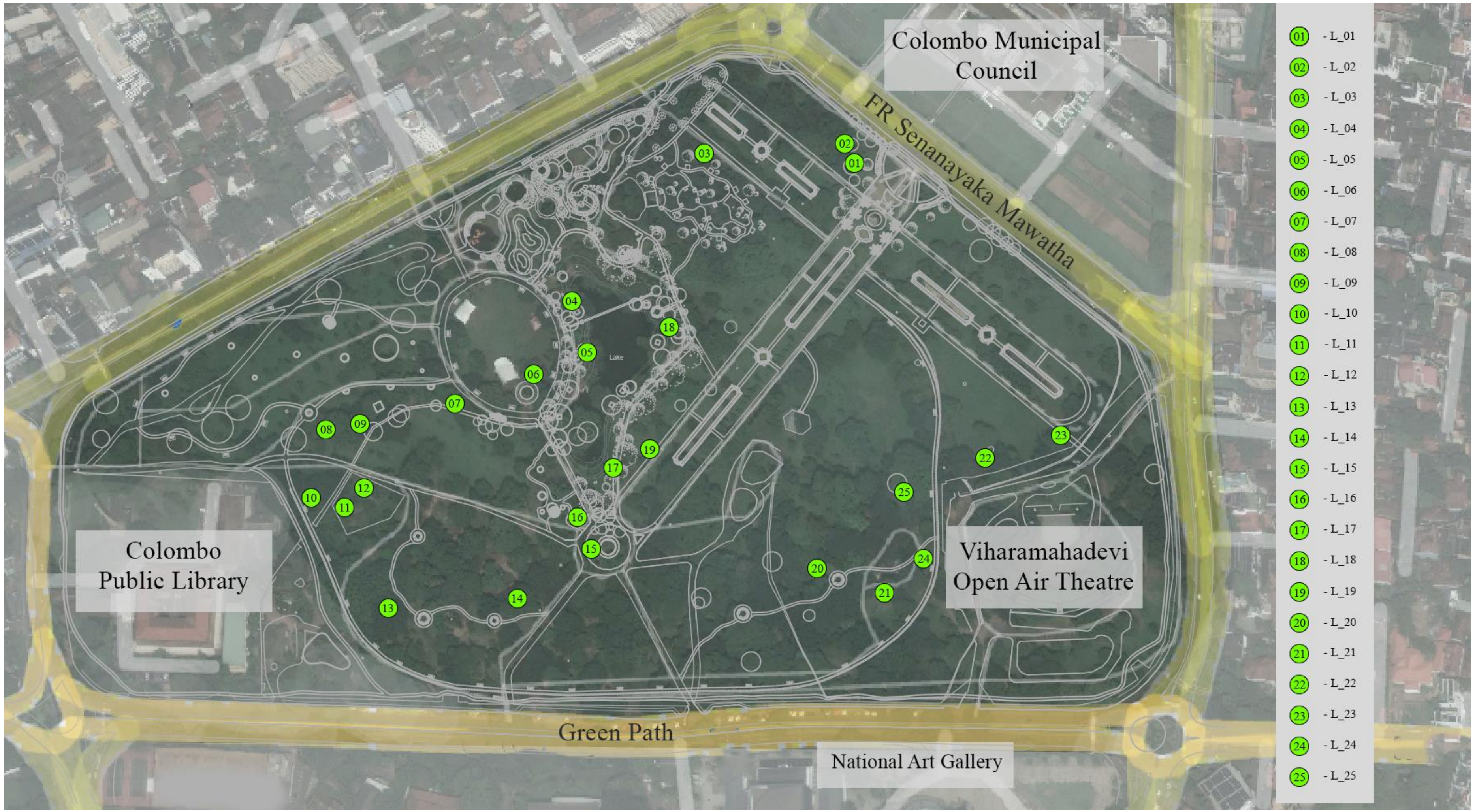
3.4.3 Case Study selection – Phase II

This study concerns more on the different configurations of the spaces created by the vegetation placements and their impact on the sense of safety and comfort of the users. The case study location ideal for the research should compromise of green covering most of the visual frames and be located in an urban area. The park should be active, and users should be using the space freely as per their will. There should not be restrictions of using the space. Thus, all nature sensitive spaces with restricted use have been eliminated as there are restrictions to the use of such spaces. Most typical types of vegetation configurations should be found in the selected space. Vihara Maha Devi Urban Park is chosen as the research's case study in light of all of these factors. The most significant urban park, this one is well-liked for its convenient accessibility and ideal setting for outdoor recreation. The park contains a large variety of trees and a body of water. Users are free to use most of the areas for leisure, exercise, and other recreational activities. In 2013, the Vihara Maha Devi Park had a makeover where fences and gates were removed enabling the users to enter from anywhere, they preferred. The pruning of the trees made visual links to either side of the park creating sense of safety of the users. The comfort is provided to the users through allowing their privacy while maintaining the societal norms. The park premises and the surrounding are frequently used for rallies, protests and other political agendas as this is a public space which allows people to express themselves. Whenever these happens, extra personnels from police and armed forces are enabled to ensure the safety of the users. Apart from these there are police and armed forces on the park premises daily to ensure the safety of the users. This is done due to the high vulnerability of the park premises for protests and other uncivilized activities. However, no major events regarding threats and discomfort to the users have not been recorded in the near past (Planning Officer - Vihara Mahadevi park, personal communication, December 20, 2023).

For the selection of the locations in the park, the researcher had 5 prior visits to the park on 2 weekdays and 3 weekends for analysing the spaces frequently used by the users. These spaces were marked on a map for all 5 visits and the spaces with more than 3 markings (people have used this space for relaxing or any other activity in more than 3 days) were selected as the ‘units of analysis’ or the ‘locations’ for this study. All 5 visits were carried out in bright sunny days where the use of turfed areas is free and no clogged water or any other element restricts the moves. All the selected areas were surrounded mainly with vegetation and little man-made features were visible only in few of the selected spaces. Some of these spaces had designed seating while some did not (people used these spaces as picnic spaces and sat on turf or ground). When there are similar spaces very close to each other with similar vegetation qualities, only the most frequent space by users is selected. The 25 selected spaces for the study are shown in figure 3.7 below.

Figure 3.7

Selected 25 case study locations for the study.



The characteristics of each space are objectively determined by the above-mentioned methods under section 3.4.2.

3.4.4 Sample Selection – Phase II

Random sampling is used to choose the sample of respondents for data collection in the case study premises. Apart from the 5 visits to select the spaces, another 6 different visits (5 weekends and 1 weekday) were carried out targeting the users of the selected spaces. More than 20 responses were obtained from each location with the developed self-assessment tool from phase I and some additional questions for a better insight into their preference for the particular space. If there are no users at the exact same space but in a very close space, then such users are selected as possible respondents, and the exact space is referred and asked them to correspond considering an overall experience of the space. This data was collected by researchers and a colleague with similar background and experiences. The users who used the selected spaces during the morning hours (9am – 11am) and evening hours (3pm – 6pm) were selected for the study.

The researcher would first interact with the user in a friendly conversation and introduce oneself and explain about the research and other basic details. Secondly, the researcher would obtain the individual's consent for the data recording and either give them the printed questionnaire or obtain the answers in a friendly interview type conversation (as per the preference of the user). All the responses were obtained in a 7-point rating scale (1 – extremely low agreement, 2 – very low agreement, 3 – low agreement, 4 – agreement, 5 – high agreement, 6 – very high agreement, 7 – extremely high agreement) allowing the respondents to provide a reasonable answer reflecting their experience at the space. The collected information is recorded and analysed using appropriate statistical or any other appropriate method.

Onsite user responses are the primary data collected through the process. But it is also researched that the psychological aspects of perception focus more on the sight (Karmanov, 2009) and sometimes the temporal conditions onsite can interfere with the psychological aspects of concern (Caldera & Perera, 2018; Klemm et al., 2015). Thus, 20 more responses were obtained through photographic evaluation for each location for confirmation on this fact. These individuals were selected through snowball sampling where first some known individuals were reached and asked them to spread the link to their contacts. No limitations on age or any other factor were considered in the process. Only one case was sent to one person and as a result there is no impact from comparisons in the process. Subsequently, the responses from both categories are to be used in the analysis process if there is statistically significant similarity between the two categories of respondents.

Figure 3.8

A summary on the data collection procedures and methods used in this study.

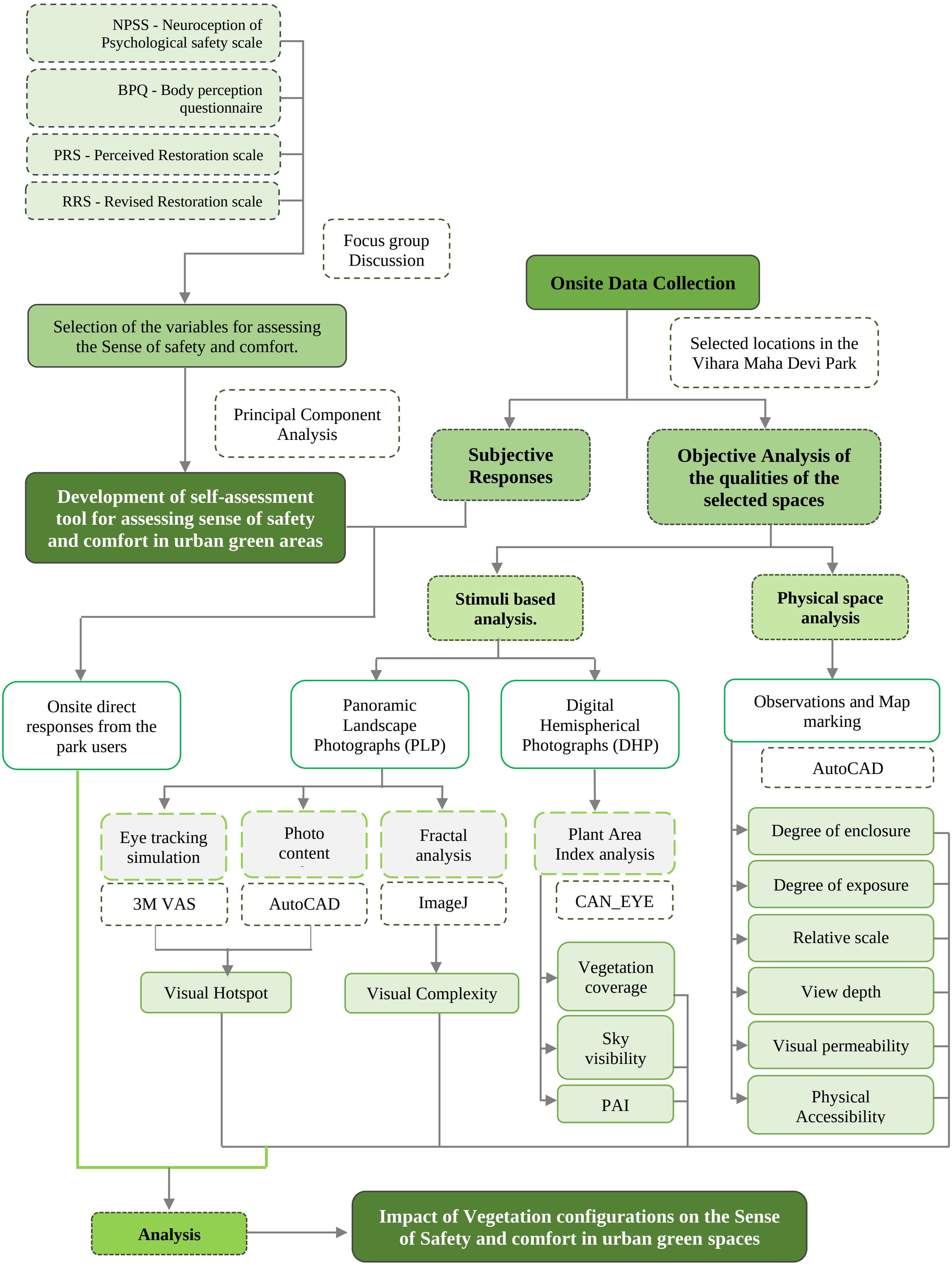
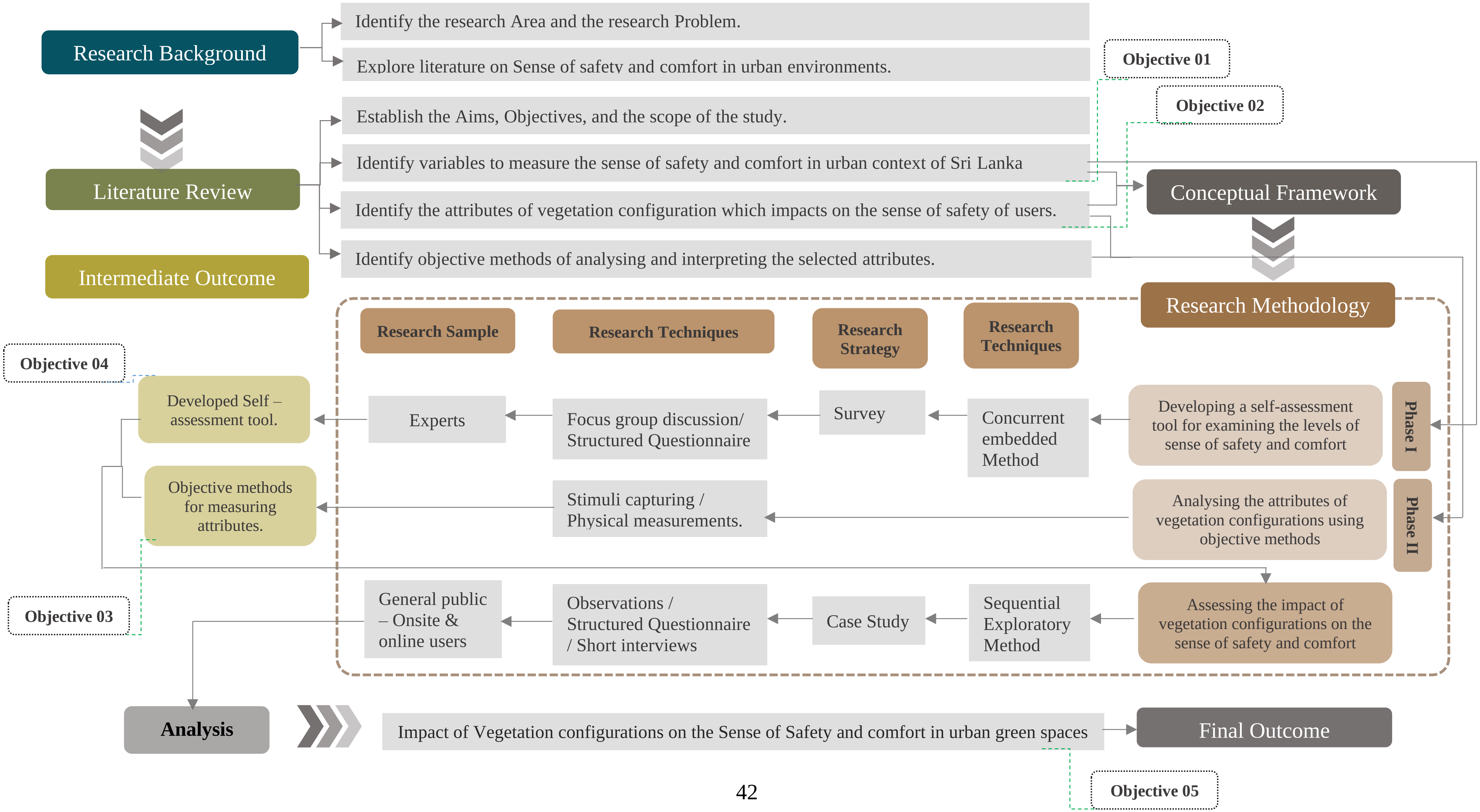


Figure 3.9

Summary of the research design as developed by the Author.



CHAPTER 4

DATA ANALYSIS AND RESULTS

4.1 Results of Principal Component Analysis – Phase I

4.1.1 Introduction

Principal component analysis (PCA) is a widely used technique used for the dimensional reduction and identifying patterns in the multivariate data. As many data sets compromises of high dimensional information, extracting these into meaningful interpretations is essential while retaining the most important information. PCA addresses these aspects by converting original variables into new sets of uncorrelated variables known as the ‘principal components’ (Beaumont, 2012).

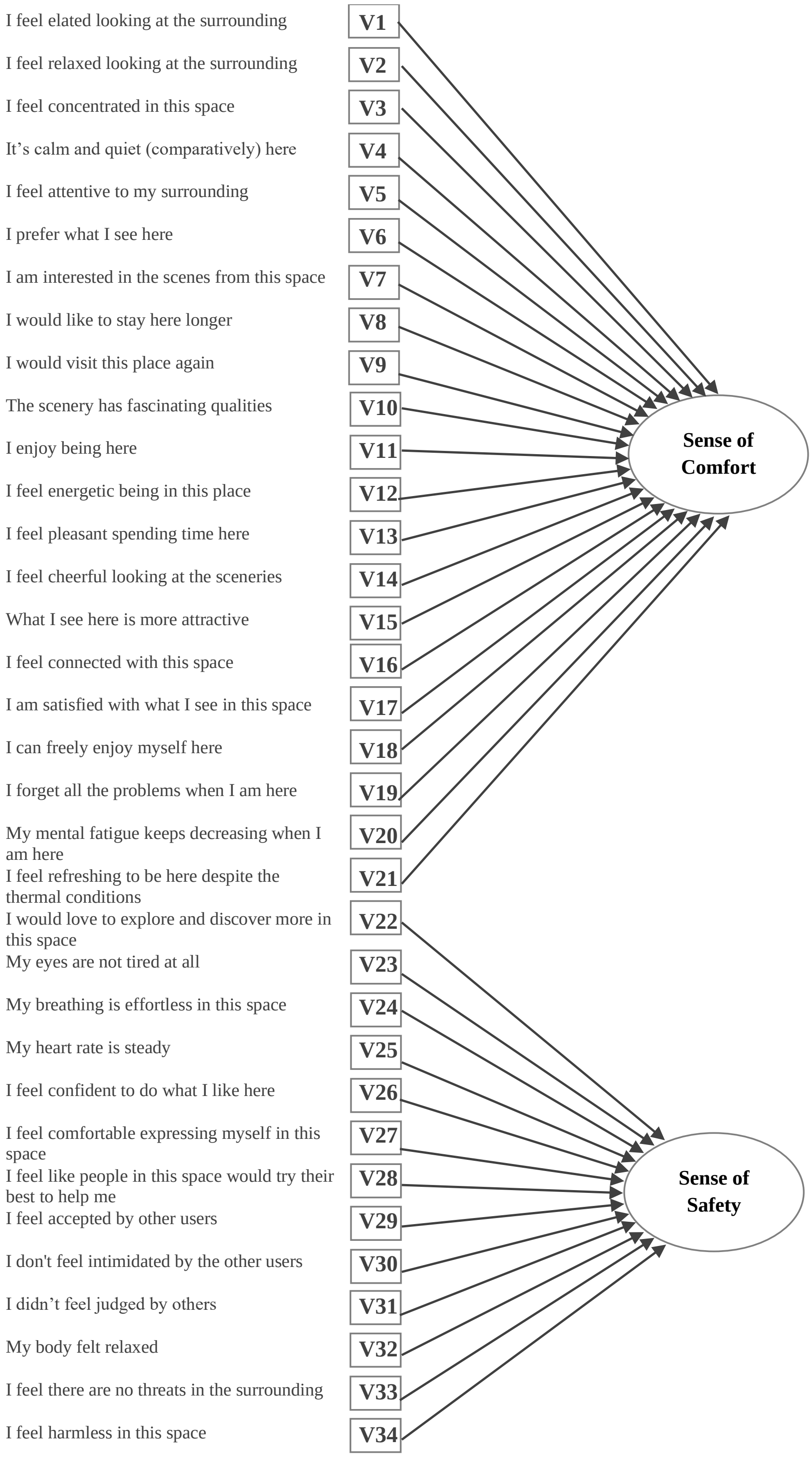
4.1.2 Data set Description

PCA converts original variables into a new uncorrelated set of variables which are designed to capture the maximum possible variance present in the data set. The selected 34 variables were analysed with PCA for a better understanding of the patterns, better visualization, modelling and extracting meaningful insights of the data. A total of 174 responses were collected from the experts in the course of 3 months (using a 7-point rating scale as mentioned in the methodology section) and these responses were analysed with the use of the SPSS software (Statistical Package for Social Sciences–developed by Norman H. Nie, Dale H. Bent, C. Hadlai Hull, initial release:1968, Country: USA).

The survey data responses collected for this study shows considerable levels of correlations among the variables selected (See Appendix B). In case of multicollinearity among the variables, PCA is considered as the most reliable in reducing the dimensionality while minimizing the loss of important information (Björklund, 2019).

Figure 4.1

The selected 34 variables (through focus group discussions) for the Principal Component Analysis


I feel elated looking at the surrounding
V1
I feel relaxed looking at the surrounding
V2
I feel concentrated in this space
V3
It's calm and quiet (comparatively) here
V4
I feel attentive to my surrounding
V5
I prefer what I see here
V6
I am interested in the scenes from this space
V7
I would like to stay here longer
V8
I would visit this place again
V9
The scenery has fascinating qualities
V10
I enjoy being here
V11
I feel energetic being in this place
V12
I feel pleasant spending time here
V13
I feel cheerful looking at the sceneries
V14
What I see here is more attractive
V15
I feel connected with this space
V16
I am satisfied with what I see in this space
V17
I can freely enjoy myself here
V18
I forget all the problems when I am here
V19
My mental fatigue keeps decreasing when I am here
V20
I feel refreshing to be here despite the thermal conditions
V21
I would love to explore and discover more in this space
V22
My eyes are not tired at all
V23
My breathing is effortless in this space
V24
My heart rate is steady
V25
I feel confident to do what I like here
V26
I feel comfortable expressing myself in this space
V27
I feel like people in this space would try their best to help me
V28
I feel accepted by other users
V29
I don't feel intimidated by the other users
V30
I didn't feel judged by others
V31
My body felt relaxed
V32
I feel there are no threats in the surrounding
V33
I feel harmless in this space
V34
Sense of Comfort
Sense of Safety

Initially, the factorability of the 34 variable items (although the items were used for assessing two aspects, the factorability check was done as a whole) was assessed. A number of widely accepted standards for a correlation's factorability were applied. First, reasonable factorability was suggested by the significant number of variables that correlated at least .3 with (at least) one other item. Second, Bartlett's test of sphericity revealed a significant result (x2 (174) = 2729.007, p<.000), and the Kaiser-Meyer-Olkin measure of sampling adequacy was.792, higher than the advised value of.7. Ultimately, All the communalities were all greater than.4 (See appendix B), indicating that every item had a common variance with the others. All 34 variables were used in a factor analysis based on these overall indicators. (ignoring the two aspects of sense of safety and comfort).

4.1.3 Eigenvalues and Explained Variances

Since the main goal was to identify and calculate composite coping scores for the factors that are relevant for gauging sense of safety and comfort in urban green spaces, principal components analysis was carried out using oblimin rotation. The first factor explained 19% of the variance, the second factor 20.317%, and the ninth factor 3.035% of the variance, according to the initial eigen values. During several steps (3), a total of 16 variables (V1 – V4, V10, V16 – V18, V21, V22, V26 – V28, V32 – V34) were removed because they did not contribute to a simple factor structure and did not fulfil the minimum criterion of having a primary factor loading of .55 or above, and no cross-loading of .3 or above. The final eigen values and the explained variances are shown in table 5.1 along with the scree plot in figure 5.2 (which simply displays the same data). The final number of components selected for the study is six where 71.147% of the variance is explained and with eigenvalues above 1.

Table 4.1

The eigenvalues and the total variance explained by the components.

Total Variance Explained

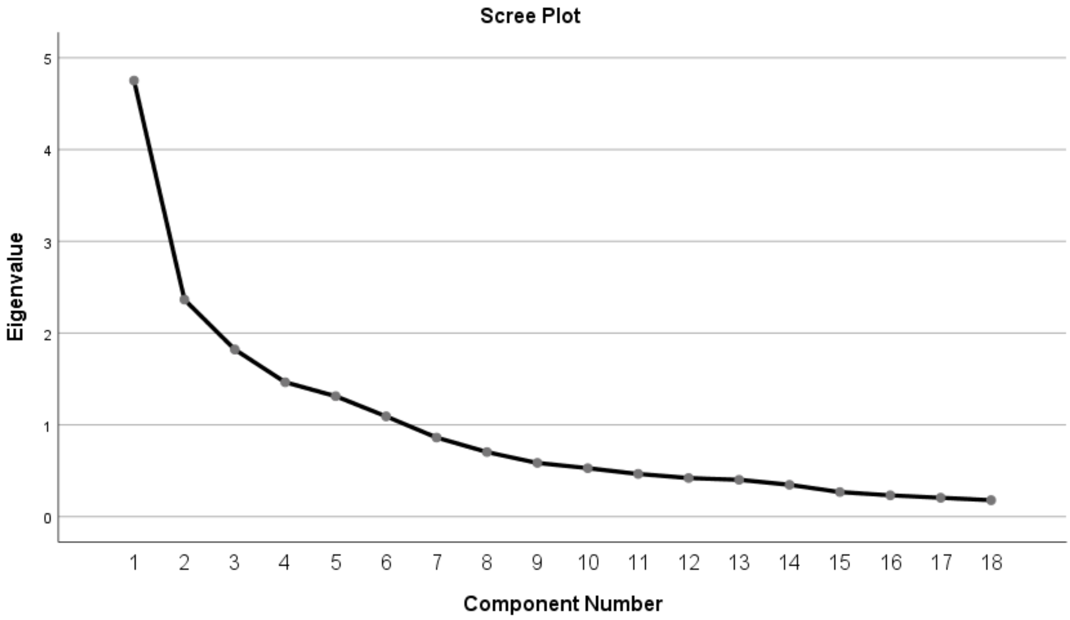
Component	Initial Eigenvalues			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total
1	4.752	26.400	26.400	3.682
2	2.365	13.139	39.539	2.403
3	1.821	10.116	49.655	2.013
4	1.464	8.131	57.787	1.698
5	1.312	7.291	65.078	2.975
6	1.092	6.069	71.147	2.068

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Figure 4.2

Scree plot of the PCA analysis output



4.1.4 Principal Components and Loadings

The factor loadings (also known as eigenvectors) for each principal component are shown in table 5.2. Factor loadings illustrate how much variance in the observed variable is accounted for the relevant principal component. Oblimin rotation is used in extraction of the factor loadings to make the factors more interpretable. This rotation aims to maximize the factor loadings and make each variable strongly related to one factor/ component minimizing the loadings on the variables that are unrelated to that factor/ component. The final factor loadings of the rotated matrix are shown in the table 5.2 below.

Table 4.2

Factor loadings based on PCA with Oblimin rotation ,N=174

		Components					
		1	**2**	**3**	**4**	**5**	**6**
V11	I enjoy being here	.808					
V13	I feel pleasant spending time here	.805					
V12	I feel energetic being in this place	.803					
V14	I feel cheerful looking at the sceneries	.747					
V15	What I see here is more attractive	.596					
V24	My breathing is effortless in this space		-.846				
V23	My eyes are not tired at all		-.786				
V25	My heart rate is steady		-.768				
V6	I prefer what I see here			.794			
V7	I am interested in the scenes from this space			.741			
V5	I feel attentive to my surrounding			.702			
V8	I would like to stay here longer				.860		
V9	I would visit this place again				.802		
V30	I don't feel intimidated by the other users					.834	
V29	I feel accepted by other users					.829	
V31	I didn’t feel judged by others					.811	
V20	My mental fatigue keeps decreasing when I am here						-.851
V19	I forget all the problems when I am here						-.752

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization

4.1.5 Interpreting Principal Components

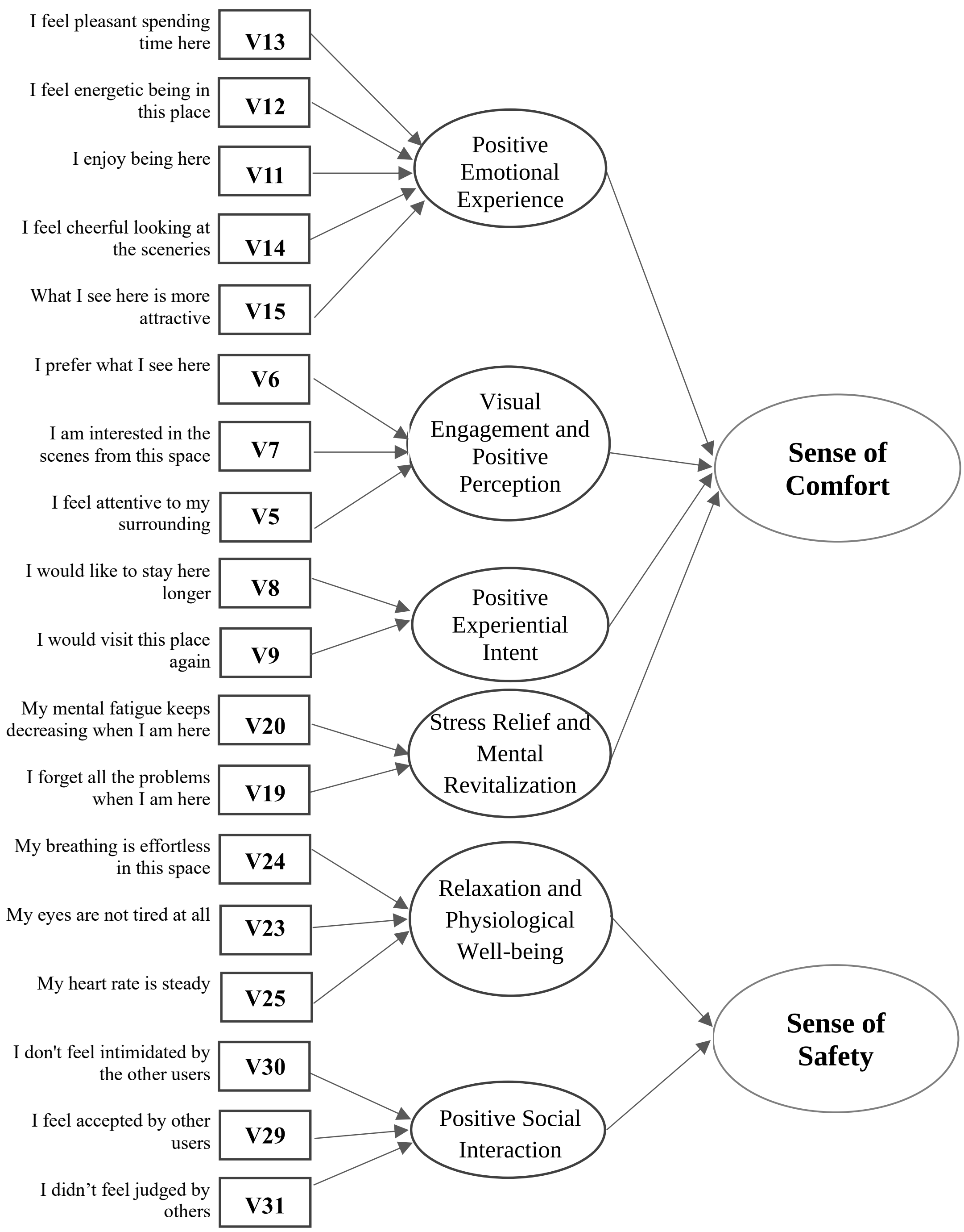
Based on the initial assigning of the variables to the sense of safety and comfort, the following principal components can be interpreted for the assurance of sense of comfort and sense of safety respectively. The principal component (PC) 1 has comparatively high loadings for all the variables along with the highest variance. This suggests that this component is highly associated with the ‘positive emotional experience’ relevant for the assurance of sense of comfort in the urban green spaces. PC3 includes variables preference to the scenes, visual frames and attention to the environment resulting in the heightened sense of perception. This component can be interpreted as ‘visual engagement and positive perception’. PC4 comprises of behavioural aspects such as staying longer in spaces and revisiting the same space. These reflect positive impressions penetrated by space and positive experiences by the users leading to a desire for prolonging their stay and returning. Thus, PC4 is interpreted as ‘positive experiential intent’. The variables are negatively loaded to PC6 interpreting an inverse relation between variables and the principal component. PC6 focuses on the environment’s influence on reducing mental fatigue and relief the everyday stressful problems. Considering these, the PC6 is interpreted as ‘stress relief and mental revitalization’. The PC1, PC3, PC4 and PC6 relates directly to the assurance of perceived comfort of the users.

All variables in the PC2 are negatively loaded which suggests that these variables are inversely related to the PC2. Considering the variables, effortless breathing, relaxed eyes and steady heart rates which claim calming and stress reducing effects, PC2 is interpreted as ‘relaxation and physiological well-being’. PC5 mainly reflects on the societal aspects like being accepted and not being judged by the users and feeling reassured while using the public green space. Considering all these facts, PC5 is interpreted as ‘positive social interaction’. PC 2 and PC 5 directly associates with the assurance of sense of safety to the users. For more comprehensive explanations on the variables under principal components see Appendix B.

It is essential to acknowledge that PCA is a tool for dimensionality reduction and pattern discovery. Interpretations are often heuristic and exploratory, serving as hypotheses for further investigation rather than definitive conclusions. The summary of the above interpretations for the PCs are illustrated in figure 5.3.

Figure 4.3

Illustration of the summary of interpretation of the principal components extracted through PCA

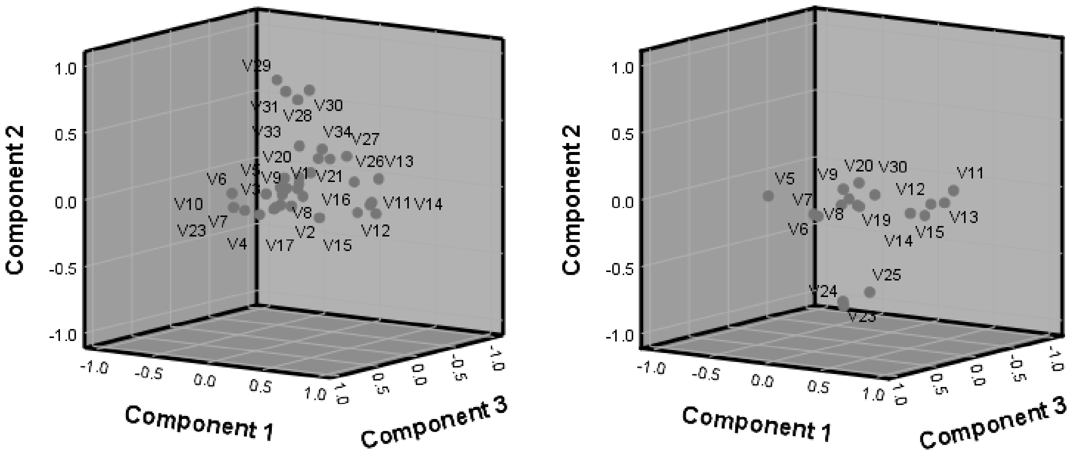

I feel pleasant spending time here
V13
I feel energetic being in this place
V12
I enjoy being here
V11
I feel cheerful looking at the sceneries
V14
What I see here is more attractive
V15
I prefer what I see here
V6
I am interested in the scenes from this space
V7
I feel attentive to my surrounding
V5
I would like to stay here longer
V8
I would visit this place again
V9
My mental fatigue keeps decreasing when I am here
V20
I forget all the problems when I am here
V19
My breathing is effortless in this space
V24
My eyes are not tired at all
V23
My heart rate is steady
V25
I don't feel intimidated by the other users
V30
I feel accepted by other users
V29
I didn't feel judged by others
V31
Positive Emotional Experience
Visual Engagement and Positive Perception
Positive Experiential Intent
Stress Relief and Mental Revitalization
Relaxation and Physiological Well-being
Positive Social Interaction
Sense of Comfort
Sense of Safety

4.1.6 Visualization

The variables plotted against the first three components (also known as the biplot) is produced as a part of the results under PCA for the better understanding of the relationships between the variables and components in the rotated space. The position of each variable is determined by the respective loading of each variable for the first three rotated components. The variables far from the mid region of the plot represent possible outliers or variables which deviate significantly from general patterns of the data set. The following bi plots with all 34 variables at the first PCA and with the finalized 18 variables (after removing the 16 variables which did not have passed the cut off of 5.5 primary factor loading and no cross loading above 0.3) show the difference in the dispersion of the variables against the first 3 components.

Figure 4.4

(1) Biplot with all 34 variables (2) Bi plot with only the 18 selected variables after performing PCA



4.1.7 Limitations and Assumptions

PCA assumes linearity and might not be suitable for all types of data. However, all the phrases selected as the variables (34 variables) are expected to show a linear relationship. PCA, in contrast to factor analysis, assumes that there are no distinct variances that are unrelated to the variables. In the case of PCA, the total variance equals the common variance.

4.1.8 Advancing with PCA results

The PCA results obtained as the first phase of this research is intended to be used as the basis for the second phase of the study which explores the impact of the calculated safety and comfort scores for the different vegetation configurations. The first phase concludes the final variables to be used in the onsite data collection through dimensionality reduction.

As the PCA is conducted using expert scores, it is assumed that the numbers are more reliable and replicable when compared with the data obtained from other sources. The experts were asked to rate the variables considering the conditions of Sri Lanka and other relevant aspects in the use of urban green spaces. Thus, the results can be reflected in the analysis of the data obtained at urban green spaces. Following this claim, the results of the PCA is to be used for the next phase of the study to calculate scores for each component as well as a final score for the sense of safety and sense of comfort for each respondent. For this the resultant numbers from the above PCA analysis will be used.

4.1.8.1 Separate Component Scores for Observation

Each respondent in the process of the data collection will fill out a questionnaire with 18 questions (18 finalized variables as per the results from PCA) for a particular location in the selected case study (Vihara Maha Devi Park). These will be used to produce separate scores for components for each observation (each respondent). This will be conducted as a weighted mean across the responses based on the factor loadings in the PCA analysis in phase one.

Computation of the component scores for the principal component PC1 for observation ì will be as follows.

Observation ì will have *n* number of responses for *n* number of questions presented through *n* number of variables (18 questions/ variables for this situation). Let's assume these numbers are q1, q2, q3, …… q*n*. Let's assume there will be *m* number of principal components extracted. The pattern matrix will be as follows (table 5.3). Let's assume the loadings (L) for PC1 as L1-1, L1-2, L1-3,…., L1-*n*.

Table 4.3

An example of the pattern matrix produced by SPSS

Pattern Matrix					
	PC1	**PC2**	**PC3**	**………**	**PC*m***
Variable 1	L1-1	L2-1	L3-1		L*m*-1
Variable 2	L1-2	L2-2	L3-2		L*m*-2
Variable 3	L1-3	L2-3	L3-3		L*m*-3
……………..					
Variable *n*	L1-*n*	L2-*n*	L3-*n*		L*m*-*n*
Most of the above values will be zero/ blank if that variable is not loaded into the respective PC					

The calculation of component score of observation ì for PC1

$$\begin{pmatrix} \text{Component score} \\ \text{of observation } i \\ \text{for } PC1 \end{pmatrix} = \frac{(\text{q1} \times \text{L1-1}) + (\text{q2} \times \text{L1-2}) + (\text{q3} \times \text{L1-3}) + \cdots + (\text{q}n \times \text{L1-}n)}{(\text{L1-1} + \text{L1-2} + \text{L1-3} + \cdots + \text{L1-}n)}$$

The above equation can be simplified as.

$$\begin{pmatrix} \text{Component score} \\ \text{of observation } i \\ \text{for } PC1 \end{pmatrix} = \frac{\sum_{i=1}^{n}(\text{q}i \times \text{L1-}i)}{\sum_{i=1}^{n}(\text{L1-}i)}$$

The same equation should be followed and the separate component scores for each principal component (*m* number of PCs in this case) should be calculated for each observation.

4.1.8.2 Separate Composite Score for Sense of Safety and Sense of Comfort of each observation

This study also expects to generate a separate composite score to obtain a better insight into the sense of safety and sense of comfort of the users. For this, two separate composite scores are to be produced through the separate principal component scores calculated as above.

First, weights should be assigned to each component extracted. This is done based on the eigenvalues obtained through the process of PCA. In this study principal components relevant for both safety and comfort is being explored. According to the PCA results, PC1, PC3, PC4 and PC6 are used for assessing the levels of perceived comfort of the users and PC2 and PC5 are used for assessing the levels of sense of safety of the users. Irrespective of the unique condition in this study, the below example illustrates a common setting where PC1 – PC*m* are categorised for a single construct. Furthermore, here it is assumed that the total variance of the latent variable is explained through the selected components for the study. As a considerable proportion of variance is addressed through the selected components, it is justifiable in the due course.

Assume *m* principal components are extracted for a single construct and their respective eigen values are as shown in table 4.4.

Table 4.4

An example of calculating the weights for each component (adjusted variance explained)

	Initial Eigenvalues	**Adjusted proportion of eigenvalues[a]**
PC1	Eg1	$(V1) = \frac{\text{Eg1}}{\sum_{x=1}^{m} \text{Eg}x} \times 100\%$
PC2	Eg2	$(V2) = \frac{\text{Eg2}}{\sum_{x=1}^{m} \text{Eg}x} \times 100\%$
……..	…………..	………….

PC*m*	Egm	$(Vm) = \frac{\text{Egm}}{\sum_{x=1}^{m} \text{Eg}x} \times 100\%$
a – The eigenvalues is adjusted considering that *m* number of components (selected components) explains 100% of the variance in the latent variable. This is different from the value produced at the SPSS output.		

The adjusted proportions of eigenvalues are the weights for each principal component selected. These are used to calculate the single composite score for each observation ì as follows.

$$\begin{pmatrix} Composite \\ score\ for\ observation\ ì \end{pmatrix} = \begin{pmatrix} Component\ score \\ of\ observation\ i\ for\ PC1 \times V1 \\ for\ PC1 \end{pmatrix} + \begin{pmatrix} Component\ score \\ of\ observation\ i\ for\ PC2 \times V2 \\ for\ PC2 \end{pmatrix} + \cdots + \begin{pmatrix} Component\ score \\ of\ observation\ i\ for\ PCm \times Vm \\ for\ PCm \end{pmatrix}$$

This can be simply illustrated as;

$$\begin{pmatrix} Single\ composite \\ score\ for\ observation\ ì \end{pmatrix} = \sum_{j=1}^{m} \left[\begin{pmatrix} Component\ score \\ of\ observation\ i \\ for\ PCj \end{pmatrix} \times Vj \right]$$

Within this study, the above single composite score will illustrate the level of sense of safety and perceived comfort for each respondent. These will be later considered for the assessment of the impact between vegetation configurations and sense of safety and comfort in urban green areas.

4.1.9 Developed Self-assessment tool for assessing the sense of safety and comfort levels in urban green spaces

By following the above analysis, the researcher has concluded the following self-assessment tool for assessing the levels of sense of safety and comfort in urban green spaces in Sri Lanka. The procedure of finalizing these variables (*v*) assured its applicability and replication in the context of tropical climates. Thus, this tool is recommended for the use in similar contexts. This tool consists of 18 variables (*v*) categorized under 6 principal components. From the 6 principal components, 4 (positive emotional experience, visual engagement and positive perception, positive experiential intent and stress relief and mental revitalization) are relevant for the assessment of sense of comfort and 2 principal components (relaxation and physiological wellbeing and positive social interaction) are for the assessment of sense of safety. With the use of the separate component scores and composite scores (as mentioned above), the levels of sense of safety and levels of sense of comfort can be calculated. This can be used to assess the existing levels of safety and comfort and improve the spaces in urban green areas to achieve safer and comfortable use for the public. The simple phrases make it suitable for the self-assessment as these are easily understood by anyone. This can also be very effective for collecting large amounts of data as the guidance needed for this tool is minimum.

Table 4.5

Developed self-assessment tool for assessing sense of safety and comfort levels in urban green spaces

Self-assessment tool for assessing the sense of safety and comfort levels in urban green spaces								
When you are in a particular space at an urban green space, how much you agree on the following phrases depending on the conditions of the space you are in?		*1 - extremely low agreement*	*2 - very low agreement*	*3 - low agreement*	*4 - agreement*	*5 - high agreement*	*6 - very high agreement*	*7 - extremely high agreement*
PC1, PC2, PC3 and PC4 are focusing on the sense of comfort at a selected space in an urban green space								
PC1 - Positive Emotional Experience								
v1	I enjoy being here	☐	☐	☐	☐	☐	☐	☐
v2	I feel pleasant spending time here	☐	☐	☐	☐	☐	☐	☐
v3	I feel energetic being in this place	☐	☐	☐	☐	☐	☐	☐
v4	I feel cheerful looking at the sceneries	☐	☐	☐	☐	☐	☐	☐
v5	What I see here is more attractive	☐	☐	☐	☐	☐	☐	☐
PC2 - Visual Engagement and Positive Perception								
v6	I prefer what I see here	☐	☐	☐	☐	☐	☐	☐
v7	I am interested in the scenes from this space	☐	☐	☐	☐	☐	☐	☐
v8	I feel attentive to my surrounding	☐	☐	☐	☐	☐	☐	☐
PC3 - Positive Experiential Intent								
v9	I would like to stay here longer	☐	☐	☐	☐	☐	☐	☐
v10	I would visit this place again	☐	☐	☐	☐	☐	☐	☐
PC4 - Stress Relief and Mental Revitalization								
v11	My mental fatigue keeps decreasing when I am here	☐	☐	☐	☐	☐	☐	☐
v12	I forget all the problems when I am here	☐	☐	☐	☐	☐	☐	☐
PC5 and PC6 are focusing on the sense of safety at a selected space in an urban green space								
PC5 - Relaxation and Physiological Well-being								
v13	My breathing is effortless in this space	☐	☐	☐	☐	☐	☐	☐
v14	My eyes are not tired at all	☐	☐	☐	☐	☐	☐	☐
v15	My heart rate is steady	☐	☐	☐	☐	☐	☐	☐
PC6 - Positive Social Interaction								

v16	I don't feel intimidated by the other users	☐	☐	☐	☐	☐	☐	☐
v17	I feel accepted by other users	☐	☐	☐	☐	☐	☐	☐
v18	I didn't feel judged by others	☐	☐	☐	☐	☐	☐	☐

4.2 Objective Analysis of the Qualities of Selected Cases.

The qualities of the environment at the selected cases in Vihara Maha Devi are analysed by the means of captured photographs and other measured data onsite. These explored dimensions of the qualities are then analysed with the subjective data collected and the relationships between respective quality is then explored.

As the initial step the summarized data for all 25 locations in the Vihara Maha Devi Park is shown in appendix D. As these locations were selected based on the user behaviours, the values may not reflect a large variety of qualities. But as these spaces are selected by the users themselves, it is expected that more interpretable insights to the relationships can be extracted through the data.

4.3 Analysis of the Subjective Data collected.

As the first task of this phase of data analysis, separate component score and a two composite scores for each respond corresponding the levels of sense of safety and perceived comfort levels in urban green spaces were generated with the acquired data from the responses. A total of 1039 responses were collected from both online and onsite users (500 online responses and 539 onsite responses). Later these responses were analysed for exploring the fact whether there is a significant difference between the two types of responses (onsite and online respondents), gender and based on their age.

The respondent category, gender of the respondents and the age of the respondents and their respective responses on the 18 questions used to assess the level of safety and comfort is first converted to separate component score for each respondent for 6 principal components and an overall composite score for each of the respondent for their respective level of safety and the level of perceived comfort in the urban green spaces.

4.3.1 Analysis of Sense of Safety and Comfort based on the Respondent Category

An independent sample t-test was performed to evaluate whether there is any difference between the responses between onsite users and online respondents.

Table 4.6

The descriptives of the different respondent categories for the 6 principal components

Respondent Category		N	Mean	Std. Deviation	Std. Error Mean	Cohen's D
Positive Emotional Experience	Onsite users	539	5.105	0.794	0.034	-0.0332
	Online respondents	500	5.130	0.711	0.032	
Relaxation and Physiological Well-being	Onsite users	539	4.660	0.973	0.042	-0.0904
	Online respondents	500	4.747	0.951	0.043	
Visual Engagement and Positive Perception	Onsite users	539	5.127	0.993	0.043	0.1412
	Online respondents	500	4.989	0.961	0.043	
Positive Experiential Intent	Onsite users	539	5.331	0.972	0.042	0.0215
	Online respondents	500	5.310	0.982	0.044	
Positive Social Interaction	Onsite users	539	4.660	0.986	0.042	-0.1346
	Online respondents	500	4.790	0.945	0.042	
Stress Relief and Mental Revitalization	Onsite users	539	5.405	0.897	0.039	0.1623
	Online respondents	500	5.257	0.927	0.041	
Overall Safety Score	Onsite users	539	4.660	0.762	0.033	-0.1344
	Online respondents	500	4.761	0.736	0.033	
Overall Comfort Score	Onsite users	539	5.181	0.652	0.028	0.0566
	Online respondents	500	5.146	0.607	0.027	
	Online respondents	500	5.036	0.579	0.026	

The results indicated that there is no significant difference between the onsite users and online respondents in the first principal component positive emotion and experience (t(1037) = -0.541, p = 0.589), relaxation and physiological well-being (t(1037) = -1.445, p = 0.146) and positive experiential intent (t(1037) = 0.335, p = 0.738). Also the overall comfort score shows no difference across the two categories onsite users and online respondents (t(1037) = 0.910, p = 0.363). The principal components visual engagement and positive perception (t(1037) = 2.272, p = 0.023), positive social interaction (t(1037) = -2.170, p = 0.030) and stress relief and mental revitalization (t(1037) = 2.617, p = 0.009) shows a significant difference between the onsite users and online respondents. In the case of visual engagement and positive perception and stress relief and mental revitalization, the onsite users have scored higher compared to online respondents while for the positive social interactions the onsite users have scored lower than online respondents. Similarly, the overall safety score also shows that there is a significant difference between the onsite and online users (t(1037) = -2.161, p = 0.031) where the online users have rated relatively high safety scores compared to the onsite users.

Although the t-test results show statistically significant results in some cases, the Cohen's D value which elaborates (< 0.2) on the practical difference of the two groups explain that the responses between the two categories of onsite users and online respondents are not of much difference considering all the principal components and the overall safety and comfort scores. Thus, it is assumed that there is no significant difference between the online and onsite users for this study.

4.3.2 Analysis of Sense of Safety and Comfort based on the Gender.

To find out how the male and female samples differed from one another, an independent sample t-test was used.

Table 4.7

The descriptives of the difference between gender for the 6 principal components

Gender		N	Mean	Std. Deviation	Std. Error Mean	Cohen's D
Positive Emotional Experience	Male	533	5.1177	0.7504	0.0325	0.002
	Female	506	5.1159	0.7603	0.0338	
Relaxation and Physiological Well-being	Male	533	4.7013	0.9585	0.0415	-0.002
	Female	506	4.7034	0.9690	0.0431	
Visual Engagement and Positive Perception	Male	533	5.0679	0.9466	0.0410	0.015
	Female	506	5.0534	1.0146	0.0451	
Positive Experiential Intent	Male	533	5.2976	0.9753	0.0422	-0.049
	Female	506	5.3452	0.9777	0.0435	
Positive Social Interaction	Male	533	4.7606	0.9915	0.0429	0.080
	Female	506	4.6828	0.9433	0.0419	
Stress Relief and Mental Revitalization	Male	533	5.3601	0.9095	0.0394	0.060
	Female	506	5.3055	0.9196	0.0409	
Overall Safety Score	Male	533	4.7224	0.7574	0.0328	0.035
	Female	506	4.6961	0.7444	0.0331	
Overall Safety Score	Male	533	5.1656	0.6174	0.0267	0.004
	Female	506	5.1630	0.6444	0.0286	

The t-test results revealed that there is no significant difference between males and females for any principal component considered (positive emotional experience ($t(1037) = 0.039$, $p = 0.969$), relaxation and physiological well-being, ($t(1037) = -0.035$, $p = 0.972$), visual engagements and positive perception, ($t(1037) = 0.238$, $p = 0.812$), positive experimental intent ($t(1037) = -0.786$, $p = 0.432$), positive social interaction ($t(1037) = 1.293$, $p = 0.196$), stress relief and mental revitalization ($t(1037) = 0.962$, $p = 0.369$) and overall safety score ($t(1037) = 0.566$, $p = 0.571$) and comfort score ($t(1037) = 0.068$, $p = 0.945$). This was further proved by the Cohen's D value (< 0.1) which elaborates the practical difference between the groups. This concludes that the responses collected did not show any difference between the males and females and can be assumed as similar.

4.3.3 Analysis of Sense of Safety and Comfort based on the Age.

As there are more than 2 groups, one way ANOVA (Analysis of variance) was used for analysing the difference between the categories of age. The results show that there is no significant difference between the age groups in the responses provided for the principal components positive social interaction and ($F(5,1033) = 1.702$, $p = 0.131$) stress relief and mental revitalization ($F(5,1033) = 0.485$, $p = 0.787$). There is a significant difference between age groups for the positive emotional experience ($F(5,1033) = 7.195$, $p < 0.000$). The post hoc test Tukey HSD reveals that the responses of the age category 17 years or younger are significantly different than the other age groups. Similarly, principal components relaxation and physiological well-being ($F(5,1033) = 10.988$, $p < 0.000$), visual engagement and positive perception ($F(5,1033) = 5.606$, $p < 0.000$), positive experiential intent ($F(5,1033) = 2.737$, $p < 0.000$), showed that there is a significant difference between the age groups. In the case of relaxation and physiological well-being, similar responses were shown by all respondents from age 36 and older. In the case of visual engagement and positive perception, the responses of users from 55 years and younger were similar.

The ANOVA results for the overall safety ($F(5,1033) = 6.967$, $p < 0.000$) and overall comfort scores ($F(5,1033) = 6.878$, $p < 0.000$) depict that there is a significant difference between the different age groups. In both these cases, older, adults (medium age category) and young users had similar responses.

4.4 Assessing the Impact of Vegetation Configurations on the Sense of Safety and Comfort

Phase II of the study comprises of a large range of data types (generated through software, physical measurements etc.) Thus, for the ease of understanding the author will report the data in different sections. Some attributes were analysed as a whole while some were analysed separately. Respective reasons for this categorization in analysis is mentioned at the cases where data were not used with relation to others.

4.4.1 Impact of Visual Hotspots on Sense of Safety and Comfort

The characteristics extracted from the PLPs were analysed separately as these characteristics are entirely based on the outputs from the 3M-VAS software. As a result, the effects of each on the overall composite score for the sense of safety and perceived comfort in urban green spaces were examined separately.

The analysis employs stepwise linear regression, which carefully selects the variables to be included in the best-fit model as it builds a linear regression model. Stepwise linear regression is a combination of forward and backward regression models where forward regression begins with no variables and gradually add each variable to the model while backward regression starts with a set of variables and gradually removes variables until the results are optimal (Castle et al., 2011; Harrell, 2001; Whittingham et al., 2006). Stepwise regression also resolves the problem of multicollinearity present in the dataset (Berg, 2018). Although this method has drawbacks when there are large number of explanatory variables. But this study has only 12 variables which makes stepwise regression suitable for the analysis of data (Schirpke et al., 2022; Tasser et al., 2023).

The 12 variables (HP, HP_{area}, HP_{mean}, HP_{mean_w}, HP_{max}, HP_{min}, HP_{max_area}, VE_{edges}, $VE_{intensity}$, $CLR_{red\text{-}green}$, $CLR_{blue\text{-}yellow}$, HP_{veg}) were used as the independent variables/ attributes while the final scores for safety and comfort for each respondent was used as the dependent values for the analysis in the SPSS software package. The below tables represent the outputs of the stepwise regression for the sense of safety scores and the sense of comfort scores.

Table 5.7 and 5.8 illustrates the output of the stepwise regression for the sense of safety scores (output of 4th model) and sense of comfort scores respectively (output of 5th model). Only the eye tracking simulation predictors with tolerance > 0.01 and variance inflation factor (VIF) < 10 are included in these two models for the collinearity diagnostics. Every attribute that doesn't fit the criteria is eliminated from the analysis.

Table 4.8

Output of the stepwise linear regression on the attributes of Hotspot analysis with the overall safety score.

Attributes	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	8.728	.221		39.541	.000		
HP_{min}	-.066	.003	-.679	-22.239	.000	.622	1.608
HP	-.150	.020	-.228	-7.471	.000	.624	1.603
HP_{max_area}	-.046	.007	-.171	-6.224	.000	.764	1.308
HP_{area}	.003	.000	.163	6.160	.000	.830	1.205

The overall model fit for the above output, or the explanatory value is $p < 0.000$; $R^2 = 0.401$; adjust. $R^2 = 0.399$. Only 4 attributes out of 12 significantly impacts on the sense of safety score. The R^2 and adjusted R^2 values are used to evaluate how well the selected attributes explain the variation in the dependent variable, sense of safety score. These two values indicate the model's goodness of fit. Adjusted R^2 provides a more conservative estimate of the model fit which accounts for the number of predictors included in the model.

Table 4.9

Output of the stepwise linear regression on the attributes of Hotspot analysis with the overall comfort score.

Attributes	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	8.919	.249		35.777	.000		
HP_{min}	-.061	.003	-.743	-22.977	.000	.595	1.679
HP	-.158	.018	-.287	-8.808	.000	.588	1.702
HP_{veg}	-.007	.002	-.097	-3.685	.000	.904	1.106
HP_{max_area}	-.031	.007	-.139	-4.577	.000	.678	1.474
HP_{max}	.007	.002	.102	3.702	.000	.818	1.222

The overall model fit for the above output, or the explanatory value is $p < 0.000$; $R^2 = 0.598$; adjust. $R^2 = 0.358$. Only 5 attributes out of 12 significantly impacts on the sense of comfort score.

Based on the unstandardized B coefficients the following summary table is developed based on the fact how each attribute of hotspot analysis affects sense of safety and sense of comfort.

Table 4.10

Summary of the impact of hotspot attributes on the sense of safety and sense of comfort of the users

Sense of Safety		Sense of Comfort	
HP_{min}	Negative	HP_{min}	Negative
HP	Negative	HP	Negative
HP_{max_area}	Negative	HP_{max_area}	Negative
HP_{area}	Positive		
		HP_{veg}	Negative
		HP_{max}	Positive

Based on the above summary a discussion of the impact on the attributes to the sense of safety and comfort is provided. The B coefficient values of the results illustrates that $HP_{min,}$ HP, and HP_{max_area} is negatively affecting both the sense of safety and comfort scores while HP_{veg} affects negatively only to the sense of comfort of the users. This indicates that a PLP's total user safety and comfort will decline as the number of hotspots (HP) increases. An increase in the likelihood that the hotspot with the lowest probability will be the initial eye tracking movement (HP_{min}) will also reduce the safety and comfort scores. Which simply means if the lowest probability displayed in one

PLP (A) is higher than another PLP (B); A>B; then the level of safety and comfort of A will be lower than B. Similarly, the increase in the estimated area of a top hotspot or higher coverage of the hotspot with high probability (HP_{max_area}) will yield into a decrease in the levels of sense of safety and comfort. The proportion of vegetation captured within the hotspots identified by the eye tracking simulation software (HP_{veg}) impacts negatively on the sense of comfort of the users. Higher the vegetation area within the hotspot, the users feel uncomfortable in spaces with such views. This attribute affects negatively only to the sense of comfort of the users visually.

Furthermore, the increase of HP_{area} will result in the increase of the levels of sense of safety while the increase in HP_{max} will affect positively on the sense of comfort for the users. This means if the total area covered by hotspots (HP_{area}) is high then spaces with such views are more likely to score high with respect to the sense of safety of the users while if the probability of the top hotspot is high in a PLP (HP_{max}) is high, then it is highly likely that users will rate such PLPs as spaces with high sense of comfort.

The quality and distribution of interesting objects in the users' immediate surroundings influence how they perceive the landscape. (Henderson et al., 2007; Qiu et al., 2021). In a study conducted by Cottet et al., (2018) describes that the hotspots are coincided with the elements people usually refer when judging a landscape (Schirpke et al., 2022). However, the selection of the hotspots and the ability to judge a landscape based on this change with the type of research and of course with the sample of the study. In an ongoing research study, visual saliency is not as important because cognitive factors primarily control how people perceive space. (Henderson et al., 2007). As a result, the computer-generated results can have a different impact than the actual cognition of the users resulting in less significant results.

4.4.2 Impact of Vegetation Qualities on the Sense of Safety and Comfort

All the other attributes which depict the qualities of vegetation configurations were then selected for a combined analysis using the same approach as above. These were used as a collection as all these predictors are real qualities of the surrounding environment. Even it is explored that the fractal dimension coefficient corresponds to the external qualities of the environment and relates directly to the perception of the users (L. W. G. Kawshalya et al., 2022).

A correlation analysis is carried out in search of exploring the presence of linear relationships of the attributes with sense of safety and comfort scores as there are no direct proof which supports any predicted relationships. This provided an insight into the regression modelling process. Correlation analysis predicts any multicollinearity present in the sample. When there are highly correlated attributes, they are meant be causing complications in the stability and the interpretability of the model. Thus, identifying these can make informed decisions as removing them from the regression model. A correlation coefficient above 0.7 or below -0.7 is often considered a threshold for concern (UCLA, 2022). Table 5.8 proves the fact that there are no highly correlated attributes in the data set as $r < 0.35$, $P < 0.05$; for all the attributes associated with the overall safety and comfort score.

Table 4.11

Correlation coefficients of the Vegetation qualities and Final safety and comfort scores

Correlations

	Overall Safety	Overall Comfort	Fractal Dimension	Shade levels	Sky visibility	Vegetation visibility	Degree of enclosure	Degree of Exposure	Relative Scale	Visual Depth	Visual Permeability	Physical Accessibility
Overall Safety	1											
Overall Comfort	.556**	1										
Fractal Dimension	-.142**	-.364**	1									
Shade levels	-.088**	-.212**	-.030	1								
Sky visibility	.106**	.241**	.013	-.995**	1							
Vegetation visibility	-.106**	-.241**	-.013	.995**	-1.000**	1						
Degree of enclosure	-.099**	-.205**	.270**	.218**	-.257**	.257**	1					
Degree of Exposure	.201**	.359**	.051	.168**	-.149**	.149**	-.096**	1				
Relative Scale	-.187**	-.254**	.142**	.105**	-.111**	.111**	-.069*	-.199**	1			
Visual Depth	.210**	.286**	.268**	.077*	-.054	.054	.126**	.478**	-.064*	1		
Visual Permeability	.177**	.324**	-.404**	.163**	-.130**	.130**	-.510**	.458**	.211**	.060	1	
Physical Accessibility	-.191**	-.048*	-.003	-.246**	.250**	-.250**	-.063*	.030	.345**	.057	.256**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Based on the above assumptions, the stepwise regression was carried with the overall final safety and comfort score and the 10 attributes which are directly related with the qualities of vegetation configurations (D_{fract}, PAI, DHP_{sky}, DHP_{veg}, D_ENCL, D_EXP, R_SCL, V_DEP V_PRM, P_ACS). Similar to the above stepwise regression models, the following models also contain attributes with tolerance > 0.01 and variance inflation factor (VIF) < 10 during collinearity diagnostics.

Table 4.12

Output of the stepwise linear regression on the attributes of qualities of vegetation configurations with the overall safety score

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	11.645	2.837		4.105	.000		
V_DEP	.222	.029	.235	7.753	.000	.839	1.192
D_{fract}	-4.559	1.487	-.103	-3.067	.002	.685	1.459
P_ACS	-.011	.001	-.310	-9.414	.000	.707	1.414
DHP_{sky}	.023	.003	.250	7.590	.000	.705	1.418
V_PRM	.018	.002	.296	7.363	.000	.476	2.101
R_SCL	-.014	.006	-.079	-2.492	.013	.759	1.317
D_ENCL	.009	.004	.089	2.467	.014	.585	1.711

The stepwise regression analysis has depicted the 7th model as the most ideal with the input attributes. The model's explanatory value is $p < 0.05$; $R^2 = .208$; adjust. $R^2 = .203$. 7 out of 10 input attributes are included in this model where 3 of the attributes (D_{fract}, R_SCL, P_ACS) are negatively affected on the overall safety and comfort while 4 attributes (DHP_{sky}, D_ENCL, V_DEP, V_PRM) are positively affected.

Table 4.13

Output of the stepwise linear regression on the attributes of qualities of vegetation configurations with the overall comfort score

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	32.683	2.043		15.996	.000		
D_{fract}	-14.229	1.071	-.382	-13.291	.000	.626	1.597
V_DEP	.241	.022	.303	11.113	.000	.696	1.438
DHP_{veg}	-.029	.002	-.374	-13.793	.000	.701	1.426
D_EXP	.006	.001	.190	5.659	.000	.459	2.179
P_ACS	-.006	.001	-.190	-7.018	.000	.707	1.415

V_PRM	.011	.002	.212	5.354	.000	.331	3.025
R_SCL	-.012	.004	-.076	-2.673	.008	.633	1.580
D_ENCL	.006	.003	.065	2.183	.029	.579	1.727

The stepwise regression analysis has depicted the 8th model as the most ideal with the input attributes. The model's explanatory value is $p < 0.05$; $R^2 = .468$; adjust. $R^2 = .464$. 8 out of 10 input attributes are included in this model where 4 of the attributes (D_{fract}, DHP_{veg}, R_SCL, P_ACS) are negatively affected on the overall safety and comfort while 4 attributes (DHP_{sky}, D_ENCL, V_DEP, D_EXP) are positively affected.

The regression coefficient, also referred to as the unstandardized B coefficient, expressed how much the dependent variable (total safety and comfort) would change for each unit change in the variable under consideration while the other predictor variables remained unchanged. Thus, the magnitude and the direction of this variable is important in gaining more insight to the predictor variable's relation to the dependent variable. Based on this unstandardized B coefficient, the following summary table is compiled.

Table 4.14

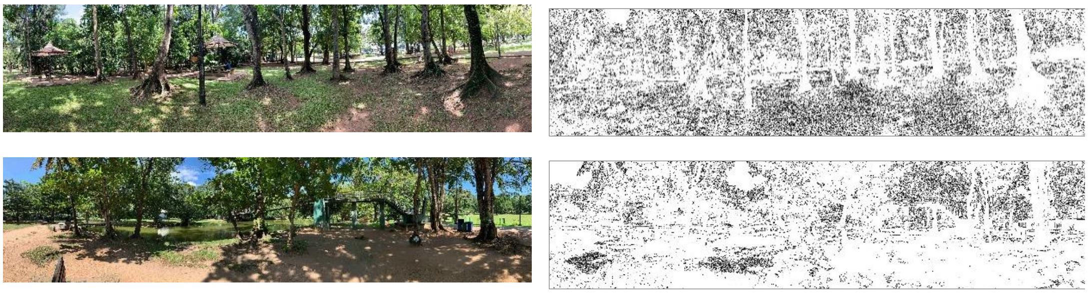
Summary of the impact of vegetation qualities on the sense of safety and sense of comfort of the users

Sense of Safety		**Sense of Comfort**	
D_{fract}	Negative	D_{fract}	Negative
V_DEP	Positive	V_DEP	Positive
P_ACS	Negative	P_ACS	Negative
DHP_{sky}	Positive		
V_PRM	Positive	V_PRM	Positive
R_SCL	Negative	R_SCL	Negative
D_ENCL	Positive	D_ENCL	Positive
		DHP_{veg}	Negative
		D_EXP	Positive

The visual complexity (D_{fract}) is the attribute with highest magnitude and negative impact with both the safety and comfort scores. One unit of positive change in the D_{fract} value will result in 4.559 units of negative change in level of sense of safety and 14.229 units of negative change in level of sense of comfort of the urbanites. The visual complexity is associate with the levels of vegetation visible for the users. According to published research, as vegetation grows, so do the "shape defining points," which are directly linked to the erratic distribution of canopy density and branching patterns. This leads to an increase in visual complexity. (L. W. G. Kawshalya et al., 2022; Ode et al., 2010). This statement was analysed with the level of vegetation/ greens captured in the PLPs and the fractal dimension coefficients calculated at the 25 locations in the selected case study. The results show that there is a considerable level of positive association between vegetation captured in the PLPs and the fractal dimension where $r(1039) = .346$, $p < 0.001$. When comparing the highest D_{fract} value PLP and lowest D_{fract} value PLP, we can easily interpret that the higher the number of shapes defining points the higher the fractal dimension coefficient and vice versa which clearly defines the visual complexity of a space. This proves that users perceive high levels of vegetation as visually complex thereby impacting on their respective levels of sense of safety and comfort.

Figure 4.5

(1) PLP of highest D_{fract}. (2) Binary image of highest D_{fract} as produced by ImageJ (2) PLP of lowest D_{fract} (4) Binary image of lowest D_{fract} as produced by Image J.

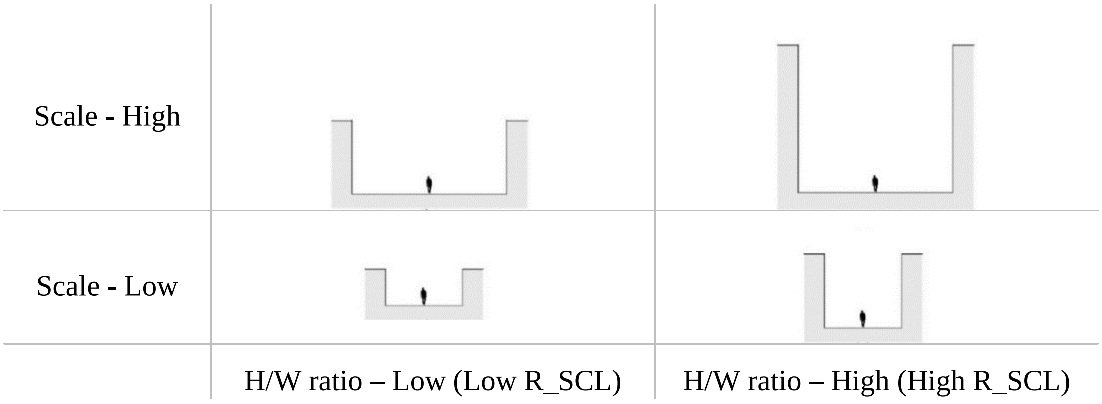


Although it is very low compared to other attributes, the physical accessibility (P_ACS) also has a negative impact on the sense of safety and comfort. This means there is a significant yet low level of impact from P_ACS on the sense of safety and comfort. If the physical accessibility increases, there is a small decrease in the sense of safety and comfort of the users. More accessible a space is, the users feel anxious of their sense of safety and comfort in that space. If a space is open to any user, then such space is vulnerable as such spaces are open to potential threats as well. Although this does not mean any physical threat, it has a direct psychological impact of feeling safer and comfortable.

Similarly Relative scale (R_SCL) is also significantly impacting negatively on the sense of safety and comfort scores of the users. The relative scale is the proportion of relative height and the relative horizontal distance to the closest elements in the surrounding. This height to width ratio is discussed frequently in recent literature rather than separate height and width parameters (Aung, 2020; Haile, 2019; Kim, 2017). This is because the perception of the users is always associated with the combination of these two factors rather than a single factor alone. This combination provides a sense of enclosure for the users in the psychological perception of space. According to the results it is evident that the users prefer low relative scales for ensuring the sense of safety and comfort while using the urban green spaces. Low relative scales predict low heights and longer horizontal distances.

Figure 4.6

The change in R_SCL with changing H/W ratio



These low relative scale environments are ideal in the resting and relaxing spaces (parks, squares, plazas) as they allow high horizontal field of view and high vertical fields of view assuring the sense of safety of the users (Kim, 2017). Similar study by Haile (2019) states that the maximum and minimum height to width ratios at squares should be 1:6 and 1:4 respectively (Haile, 2019). These confirms the findings of this study where low relative scales are associated with high levels of sense of safety. Although many spaces do not fulfil this condition at Vihara Maha Devi Park, the spaces which fulfil this has recorded comparatively high safety and comfort scores.

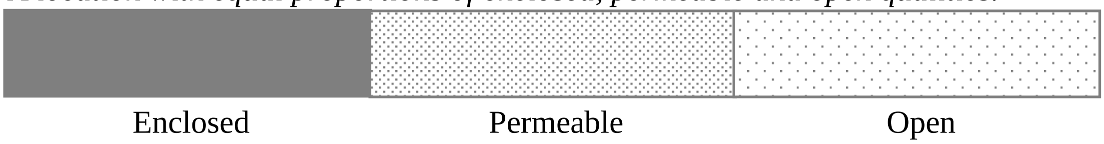
DHP_{veg} has a negative impact on the sense of comfort scores of the users. Higher the area of vegetation covered by the digital hemispherical photographs (DHPs), the level of sense of comfort of the users are low. Although many literature sources suggest that the visibility of the greens increase the visual comfort of the users, the result of this study suggests otherwise. But it is important to note that this attribute focus on the vertical projection of view at a point. Unlike the tree coverage at a normal view angle of an individual, this attribute considers what is covered with the DHPs which captures the tree patterns above the normal visible angle of a human. The tree coverage of a DHP is high if the trees are located near to the observation point or if the trees have an extremely large and dense canopy. Too closely located trees or dense tree coverage can result in dark and hideous feelings in the users (Mahrous et al., 2018; Mak & Jim, 2017). This tree coverage of the vertical projection is directly associated with the sense of openness of the observation point as well (Caldera & Perera, 2018). Visibility of more trees in the DHP implies that the sky visibility is low. People specifically prefers open skies in the urban congested areas as it provides the sense of prospect which provides restoration to the users (Hunter & Askarinejad, 2015). Similar to all these reasons, Smardon (1998) declares that the relationship between the preference and amount of trees and other vegetation may be non-monotonic meaning that vegetation up to a point might be preferable and then might flatten or possibly decline based on the situations (Smardon, 1988).

Visual Depth (V_DEP) is has the highest magnitude of positive relationship with both the sense of safety and sense of comfort. The attribute visual depth explores the distance to the farthest elements seen from the observation point in a 360 degrees isovist at the eye level of an average individual. This implies the higher the V_DEP is, the higher the overall sense of safety and comfort for the users. If users can see more into the surrounding landscape, in such environments people feel safer and comfortable as a result of gaining more information of a possible threat (Batty, 2001; Chiang et al., 2014). In a study done by Schirpke et al., (2022), revealed that people focus on the central zones in their cognitive process of perception. Here the study focuses on Alpine landscape areas where the central zone is the visibility of the elements within the range 1.5km – 10km range. Although the range is quite different from this study, considering the visual accesses of the selected location this study can be concluded that the more visible area will generate more sense of safety and sense of comfort in the users.

Visual permeability (V_PRM) also has a positive and a significant impact on both the sense of safety and comfort. The measurement of visual permeability considered an area with a radius of 15m and the qualities of its views, whether the views are fully open or permeable. Similar to this attribute, the degree of enclosure (D_ENCL) also interprets a positive relationship with the sense of safety and comfort. The measurement of enclosure considered the obstructed and open views beyond 15m radius as a result of the elements in the 15m radius. These two attributes feel contradictory at the first glance, but it is important to interpret these numbers based on the data collected. It is true that the D_ENCL and V_PRM considers the same qualities in the environment. Indeed, the only measurement considered in D_ENCL is removed in the calculation of V_PRM (only open and permeable qualities are assessed and enclosure arc is removed by multiplying it by zero). Generally, a space can be either enclosed, permeable or open depending on the elements located in the 15m radius area.

Figure 4.7

A location with equal proportions of enclosed, permeable and open qualities.



Please note that the above illustration is only used for explaining a hypothetical location with equal enclosed, permeable and open qualities

Let’s consider the minimum and maximum values of the 25 selected locations for this study. The table 5.10 illustrates the maximum and the minimum values for the respective attributes based on the 25 selected locations.

Table 4.15

Minimum and maximum values for the D_ENCL and V_PRM

	D_ENCL	V_PRM

Minimum	3.889	39.167
Maximum	36.667	81.806

Depending on the above values only, the regression model has compiled the relationships between each attribute with the overall safety and comfort score. So, the increase of V_PRM and D_ENCL means the increase of the respective qualities in the range of above numbers.

Figure 4.8

The changes in D_ENCL and V_PRM explained with respect to the data set

3.889	**D_ENCL**	36.667

Increase of D_ENCL values depending on the data set

39.167	**V_PRM**	81.806

Increase of V_PRM values depending on the data set

Thus, it can be concluded that the increase of both attributes in the mentioned levels makes the regression out more interpretable. Combination of both these attributes can be illustrated as, the users feel safer and more comfortable at the locations with approximately 1/3rd (33%) of the Isovist is enclosed and at the locations with 4/5th (80%) of the Isovist is permeable allowing views beyond the observation point. Similar to this, Jorgensen et. al, (2002) found that the dense vegetation obstructed the visual accessibility thereby decreasing the perceived safety of the users. It is further proven that the penetration is an important aspect in the perception and preference on the forest like settings (T. R. Herzog & Kutzli, 2002).

DHP_{sky} has a positive impact on the overall score of sense of safety. This is the proportion of sky covered by the digital hemispherical photographs. The increase in the proportion will yield to an increase in the sense of safety of the users. The visibility of the sky is categorized as a natural element and its importance in the perception of openness for the feeling of safety. This sense of openness or the prospect gestured by the sky visibility allows an individual with time to perceive the situation and take the necessary actions thereby increasing the sense of safety (Appleton, 1975; Caldera & Perera, 2018). Similarly, this the colours of the sky provides human with the psychological effects of calmness, relaxation and peacefulness (J. W. Zhang et al., 2014). Furthermore, a study by Qiu et al. explains that perceived safety is associated with the higher sky view index (Qiu et al., 2021). It is to be noted that the sky coverage of the 25 locations of the selected case study area is less than 47%. Moreover, the high visibility of sky coverage is considered somewhere between 32% - 47% of the whole hemispherical photograph considered.

The degree of exposure (D_EXP) is an attribute which impacts positively for the sense of comfort of the users. D_EXP considers the sections of arc (in the 15m radius) where other people can observe the users at the observing point considered. If there is a pathways, security huts, adjacent residential or commercial buildings, resting or gathering areas in this vicinity, they are considered as possible areas (arc angles) with exposure. This study claims that the increase of the area of exposure to other users will result in the increase of the sense of comfort for the users. It is important to note that this attribute responds to the sense of comfort, not safety. Which means copresence of other users in the space leads to a sense of comfort but does not exactly assures safety in case of an emergency. This confirms the universal fact ‘eyes on street’, where Jane Jacobs explains that despite being among complete strangers, people still feel comfortable in public spaces (Jacobs, 1961). This is because there is a chance of help in an emergency unlike in a completely deserted space. Copresence with the other users acts as natural surveillance intending that there is help in case of a danger (Mak & Jim, 2017). Although this copresence does not guarantee safety, there is always hope. If the vegetation configuration can create a space where there are visual links to other users, then such spaces can be perceived more comfortable for the users.

From the above 10 attributes input for the stepwise regression the final models for both sense of safety and sense of comfort discarded plant area index (PAI). Apart from this, the final model for sense of safety discarded attributes vegetation visibility (DHP_{veg}) and degree of exposure (D_EXP) while final model for sense of comfort discarded sky visibility (DHP_{sky}). Thus, the author checked for a nonlinear relationship between these attributes with the overall safety and comfort score through ‘curve estimation’ in SPSS. Here logarithmic, Inverse, quadratic, cubic, compound, power, S, growth, exponential, logistic options were considered for both the cases. In all the cases all the options were displayed as highly significant ($p < 0.05$) regardless of the options. Similar characteristics across all the choices represents that there is not enough evidence to prove a relationship between the considered dependent and independent variables. This can also be due to the fact that the variation of data is not substantial enough to differentiate between each curve estimation or there might be no strong dependency between the considered attributes with sense of safety or sense of comfort. Thus, it can be concluded that more research is needed if a more significant relationship is needed to be explored between these attributes with sense of safety and comfort. Table 5.11 shows the summary of the tests performed for each selected attribute and the significance of the end results, orientation (whether the impact of the attribute with sense of safety score is positive or negative) and the magnitude (whether the association between the attribute and the sense of safety and sense of comfort is high, medium or low).

Table 4.16

Summary of the tests performed

<table>
<tr><th rowspan="2">Attribute</th><th colspan="4">Sense of Safety</th><th colspan="4">Sense of Comfort</th></tr>
<tr><th>Test performed</th><th>Significance of the results</th><th>Orientation of impact</th><th>Magnitude of impact</th><th>Test performed</th><th>Significance of the results</th><th>Orientation of impact</th><th>Magnitude of impact</th></tr>
<tr><td>VEG</td><td>Linear/ Nonlinear</td><td>N/A</td><td>N/A</td><td>N/A</td><td>Linear/ Nonlinear</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Hp</td><td rowspan="12">Stepwise Linear Regression</td><td>.000</td><td>Negative</td><td>Medium</td><td rowspan="12">Stepwise Linear Regression</td><td>.000</td><td>Negative</td><td>Medium</td></tr>
<tr><td>HP_{area}</td><td>.000</td><td>Positive</td><td>Low</td><td rowspan="3">N/A</td><td rowspan="3">N/A</td><td rowspan="3">N/A</td></tr>
<tr><td>HP_{mean}</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td></tr>
<tr><td>HP_{mean_w}</td></tr>
<tr><td>HP_{max}</td><td>N/A</td><td>N/A</td><td>N/A</td><td>.000</td><td>Positive</td><td>Low</td></tr>
<tr><td>HP_{min}</td><td>.000</td><td>Negative</td><td>Low</td><td>.000</td><td>Negative</td><td>Low</td></tr>
<tr><td>HP_{max_area}</td><td>.000</td><td>Negative</td><td>Low</td><td>.000</td><td>Negative</td><td>Low</td></tr>
<tr><td>VE_{edges}</td><td rowspan="5">N/A</td><td rowspan="5">N/A</td><td rowspan="5">N/A</td><td rowspan="4">N/A</td><td rowspan="4">N/A</td><td rowspan="4">N/A</td></tr>
<tr><td>$VE_{intensity}$</td></tr>
<tr><td>$CLR_{red-green}$</td></tr>
<tr><td>$CLR_{blue-yellow}$</td></tr>
<tr><td>HP_{veg}</td><td>.000</td><td>Negative</td><td>Low</td></tr>
<tr><td>PAI</td><td rowspan="2">Stepwise linear regression/ Nonlinear curve estimation</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td>Stepwise linear regression/ Nonlinear curve estimation</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>DHP_{veg}</td><td rowspan="2">Stepwise Linear Regression</td><td>.000</td><td>Negative</td><td>Low</td></tr>
<tr><td>D_{fract}</td><td rowspan="3">Stepwise Linear Regression</td><td>.000</td><td>Negative</td><td>High</td><td>.000</td><td>Negative</td><td>High</td></tr>
<tr><td>DHP_{sky}</td><td>.000</td><td>Positive</td><td>Low</td><td>Stepwise linear regression/ Nonlinear curve estimation</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>D_ENCL</td><td>.014</td><td>Positive</td><td>Low</td><td rowspan="6">Stepwise Linear Regression</td><td>.029</td><td>Positive</td><td>Low</td></tr>
<tr><td>D_EXP</td><td>Stepwise linear regression/ Nonlinear curve estimation</td><td>N/A</td><td>N/A</td><td>N/A</td><td>.000</td><td>Positive</td><td>Low</td></tr>
<tr><td>R_SCL</td><td rowspan="4">Stepwise Linear Regression</td><td>.013</td><td>Negative</td><td>Low</td><td>.008</td><td>Negative</td><td>Low</td></tr>
<tr><td>V_DEP</td><td>.000</td><td>Positive</td><td>Medium</td><td>.000</td><td>Positive</td><td>Medium</td></tr>
<tr><td>V_PRM</td><td>.000</td><td>Positive</td><td>Low</td><td>.000</td><td>Positive</td><td>Low</td></tr>
<tr><td>P_ACS</td><td>.000</td><td>Negative</td><td>Low</td><td>.000</td><td>Negative</td><td>Low</td></tr>
</table>

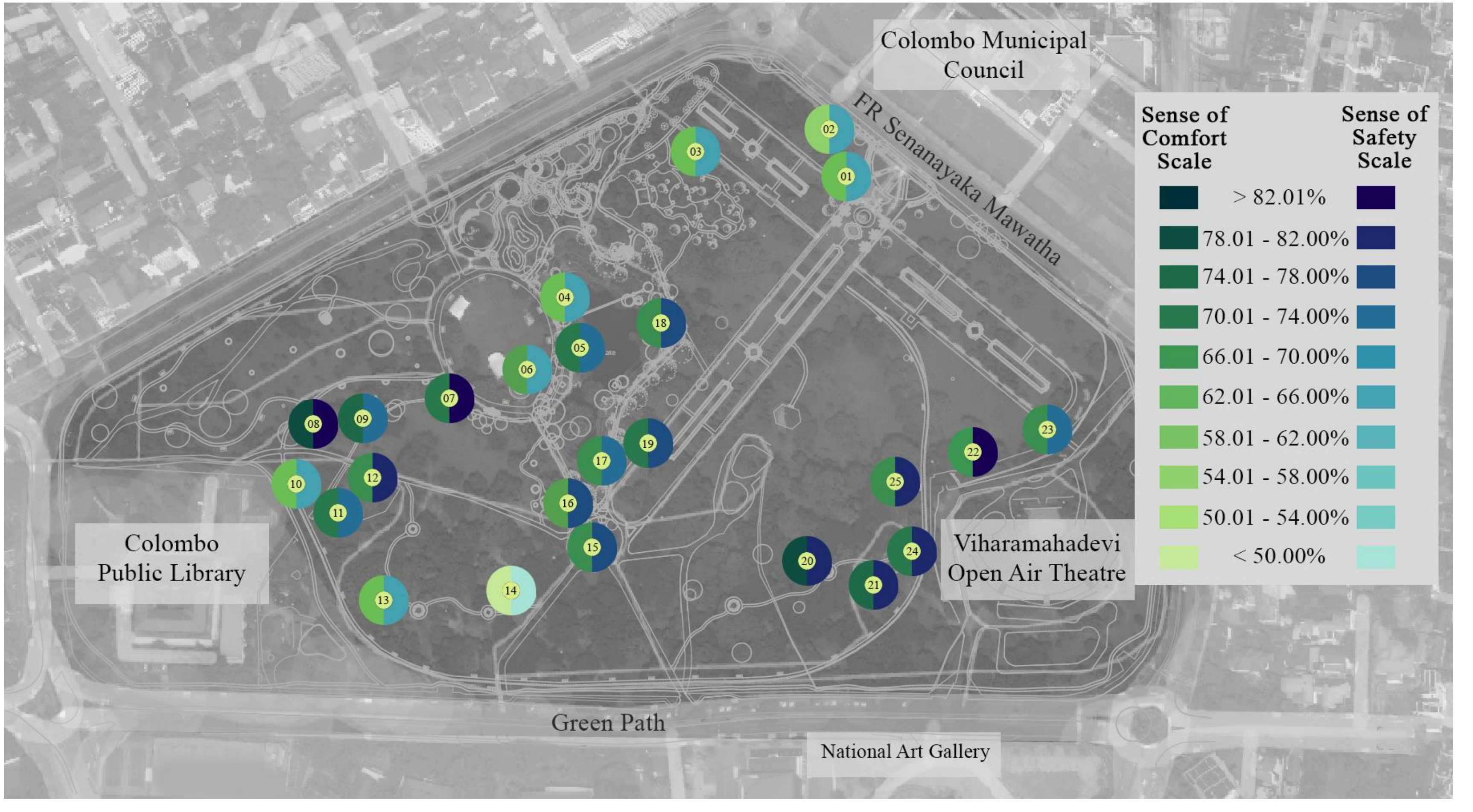
It should be noted that the author has performed two different stepwise linear regression analyses where one stepwise regression analysis focusses solely on the hotspots and the other one solely on the rest of the attributes. This is because the 3M VAS software is not a freely available software and data replicability in other contexts will be difficult with limited resources. All the other attributes assessed in this research is highly replicable in their respective methodologies as the software used are freely available and the other attributes are measured through basic measurements.

4.5 Sense of Safety and Comfort in the selected locations of the Vihara Maha Devi Park.

The respective levels of safety and comfort in the selected locations of the Vihara Maha Devi Park has been calculated using the median of the responses of both the onsite and online users. Next, a percentage is calculated based on the corresponding levels of comfort and safety. Overall, the review revealed that while the locations' senses of comfort ranged from 48.67% to 83.73%, their senses of safety varied from 38.43% to 81.22%. This demonstrated that most park locations offered visitors a comparatively higher feeling of safety and comfort. This result is illustrated in table 5-16. Location 14 (L_14) has recorded lowest scores for both the sense of safety and sense of comfort and Location 08 (L_08) has recorded highest scores for both the sense of safety and comfort. The locations selected near the open air theatre and public library had relatively high sense of safety and sense of comfort compared to the locations near to the road at the side of the Colombo Municipal council.

Figure 4.9

Sense of Safety and Sense of Comfort levels at the 25 selected locations in Vihara Maha Devi Park.



4.6 Summary of Findings

The purpose of this study is to investigate a self-assessment tool for evaluating user perceptions of safety and comfort in urban green spaces, as well as the effects of various vegetation configurations on these perceptions.

The study's initial phase creates a self-assessment tool with 34 variables to measure comfort and safety in urban green spaces. This is done primarily through referring to literature and selecting different scales which focuses on assessing psychological safety and comfort. As all the four scales are comprised of phrases which can be used for a self-assessment tool, the phrases are selected based on the contextual differences and psychological constructs of the users. A focus group discussion with 6 experts finalized the 34-variable tool for further validation. 13 variables evaluated users' sense of safety in urban green spaces, while 21 variables evaluated users' sense of comfort. An expert survey focusing on their significance in the evaluation of comfort and safety in urban green spaces served as the secondary validation for this 34-item tool. A total of 174 experts has rated these 34 variables according to their importance through a 7 – point rating scale. The responses were then analysed through a Principal Component Analysis (PCA). The results showed that the 6 principal components (PCs) extracted through the exercise explained 71.147% of the variance in the data. As all these PCs had eigen values above 1 and the variables are all important for the analysis of the sense of safety and comfort, all the 6 PCs were selected as important for the study. 2 PCs focussed on sense of safety with 6 variables (*v*) while 4 PCs with 12 variables (*v*) focussed on the sense of comfort. Thus, a total of 18 variables from 34 were categorized under the 6 PCs to evaluate different levels of sense of safety and sense of comfort of the users. The interpretation of the results identified the positive emotional experience, visual engagement and positive perception, positive experiential intent, and stress relief and mental revitalization as the PCs for evaluating the levels of sense of comfort while the relaxation and physiological well-being and positive social interaction were identified as the PCs for evaluating the sense of safety of the users. These results of the PCA are to be used in the final section of the study which analyses the impact on vegetation configurations on the sense of safety and sense of comfort of users in urban green environments.

The initial part of the study's second phase was allotted to looking for applicable techniques for evaluating the objective characteristics of vegetation configurations. With a thorough literature analysis of the theories, concepts and recent literature, 9 attributes were finalized as the primary qualities of vegetation configurations to be assessed. These are visual complexity, visual hotspots, shade levels, degree of enclosure (D_ENCL), degree of exposure (D_EXP), relative scale (R_SCL), view depth (V_DEP), visual permeability (V_PRM), and physical accessibility (P_ACS). As the second part of phase two of the study, different methods of analysing these attributed were explored. Through a thorough literature review some latest methods as well as modified conventional methods were finalized as the techniques and procedures of data collection. Two different methodologies, stimuli-based analysis and physical space-based analysis were identified in the due course. The stimuli-based analysis was conducted by panoramic landscape photographs (PLPs) and digital hemispherical photographs (DHPs). The PLPs analysed visual complexity, visual hotspots and shade levels using software analysis. The visual complexity was analysed with Fractal dimension coefficient (D_{fract}) using ImageJ software. The hotspots were analysed with 3M Visual Attention Software (3M-VAS). The shade levels were analysed with CAN_EYE software which produced the vegetation coverage (DHP_{veg}), sky visibility (DHP_{sky}) and the Plant area index (PAI) values for evaluation. The physical space analysis was carried out with observations and measurements of the spaces. The assessed attributes are D_ENCL, D_EXP, R_SCL, V_DEP, V_PRM, P_ACS. The next part of the second phase included selecting the cases and the samples. The cases were selected based on the behavioural patterns of the users. The spaces frequently used by the users for relaxation and other activities in the Vihara Maha Devi Park, Colombo were selected as the cases for this study. A total of 25 cases were selected covering the whole area of the park with abundant vegetation. At least 20 responses were selected from each selected space from the onsite survey with the use of the 18 questions finalized in phase one of the study. Apart from this an online survey was also conducted as a photographic evaluation to minimize the subjective errors due to small sample size and with temporal conditions onsite.

The final section of phase two analysed the relationship with the data obtained through the questionnaire developed in phase one and the objective data relating to the qualities of the 25 selected spaces. The responses from onsite users and online respondents did not significantly differ from one another, according to the analysis of the data. This simultaneously determines whether the users' perceptions of comfort and safety have been influenced by the physiological conditions (thermal aspects). Since there was no statistically significant difference between the two categories of users, the combination of the results from both categories was used for the final analysis of the study. A separate stepwise regression was used for the analysis of the attributes generated from the hotspot analysis from the results of the 3M VAS software. The statistical package for social sciences, or SPSS, was used for all of the analysis.

It showed that the increase in number of hotspots (HP), increase in the probability of the lowest hotspot (HP_{min}) and the increase in the area of the top hotspot (HP_{max_area}) identified through the PLPs can impact negatively on both the sense of safety score and sense of comfort score. The increase in the overall area covered by the total hotspots and the increase in the probability of the top hotspot (HP_{area}) can be positively impacted on the sense of safety of the users. Similarly, the increase in the proportion of vegetation covered in all the hotspots (HP_{veg}) and the increase of the probability of the highest hotspot (HP_{max}) will increase the sense of comfort levels of the users.

In the next step of the analysis all the other attributes (10 attributes) were analysed in another pairwise linear regression analysis to assess their respective relationship with the sense of safety and sense of comfort levels of the users. The results of this analysis showed that visual depth (V_DEP), degree of enclosure (D_ENCL), and visual permeability (V_PRM) are positively associated meaning when the values of these attributes increase both the levels of safety and levels of comfort increases. Apart from this increase in the sky visibility (DHP_{sky}) tends to increase the sense of safety levels and the increase in the exposure to the other users of the space (D_EXP) tends to increase the sense of comfort levels of the users. Furthermore, it is revealed that visual complexity (fractal dimension – D_{fract}), physical accessibility (P_ACS) and relative scale (R_SCL) attributes are negatively related to both safety and comfort meaning that an increase in these attributes will result in a decrease in the overall sense of safety and sense of comfort of the users. For further analysis, all the attributes which were dropped from the regression analysis due to not showing linear relation with the overall safety and comfort score were explored through curve estimation which yielded no proper outcome due to no affiliation seemed through the data in the collected sample. These results show the impact from the selected attributes of vegetation configuration on the sense of safety and comfort of the users.

Chapter 5

CONCLUSION

This chapter concludes the study undertaken by summarizing the key research findings in relation to the research questions and research objectives followed by a comprehensive discussion on the contribution to the academia. It will also review the limitations of the current research and propose opportunities for future research studies.

The current research study aims to answer the main research question "what is the impact of different vegetation configurations on the psychological constructs of safety and comfort in urban green spaces". To answer this, the following sub-questions are focussed.

- How can the levels of sense of safety and sense of comfort in urban green spaces be effectively measured?
- What are the key dimensions and attributes that contribute to the sense of safety and comfort of the users in urban green spaces?
- How do different qualities of vegetation configurations impact on the sense of safety and comfort of urban users?

The self-assessment tool developed with the expert discussions and survey is used for the effective measurement of the levels of sense of safety and comfort in urban green spaces. This self-assessment tool comprises of 18 variables (12 variables focused on sense of comfort and 6 variables focussed on sense of comfort) categorized under 6 different principal components where two components (relaxation and physiological well-being and positive social interaction) focus on the sense of safety and the remaining four components (positive emotional experience, visual engagement and positive perception, positive experiential intent, and stress relief and mental revitalization) concentrate on the sense of comfort. Through the development of this tool the researcher achieved the answer to the first research sub-question fulfilling the first and fourth research objectives (1) identifying the variables which are applicable for the assessment of psychological constructs of sense of safety and comfort, (4) developing a self-assessment tool for examining levels of sense of safety and comfort in green spaces of tropical cities. The literature review concluded that there is a prominent research gap in the studies related to vegetation factors with the sense of safety and comfort in the tropical climates. This developed self-assessment tool can be a major breakthrough which can be easily used for measuring levels of sense of safety and comfort. If there are spaces in urban parks which are currently underused by the users, then this self-assessment tool can be administered for users and check the current levels of sense of safety and comfort. Then after modifying the space and then again check the levels of sense of safety and comfort. Following this, the agencies can predict whether the modifications will result in a positive outcome or a negative one. This self-assessment tool can be developed into a software as well. Through the software the tool will be readily available for the users. This easy access can enhance the user contribution in the designing of public spaces as well. This tool can be ideal for the designers and planners of urban public spaces as it addresses the perception of the users where if the users have less score for positive social interaction, then that means the particular space should provide amenities to enhance the social interaction of the users. To investigate what parameters of the space should be altered or modified, the second phase of this study should be focussed.

The second research question of the study focus on the qualities of vegetation configurations which impacts on the sense of safety and comfort. Thus, in search of the different qualities, the researcher has conducted a thorough literature review, and 9 attributes were selected as the most important for investigating. These are visual complexity, visual hotspots, shade levels, degree of enclosure, degree of exposure, relative scale, view depth, visual permeability, and physical accessibility. With the finalization of these 9 qualities the researcher achieved the research objective of (2) identifying the attributes/ qualities of vegetation configurations which impacts on the sense of safety and comfort in urban green spaces of Sri Lanka. These 9 attributes were finalized with the literature data and their availability in the Sri Lankan contexts. Next the objective methods for assessing these qualities were focused to achieve the third research objective of (3) investigating the objective methods of measuring the qualities of vegetation configurations in urban green spaces. Visual complexity, visual hotspots, shade levels were assessed with stimuli analysis using panoramic landscape photographs (for visual complexity and visual hotspots) and digital hemispherical photographs (for shade levels). The rest of the attributes were measured using physical onsite measurements. The hotspot analysis incorporated an AI based analysis which focus on the attention areas when the user is projected to a particular scenery. These different methods were selected concentrating on the latest research trends which are readily available for the majority of the users. This way researcher intends to increase the applicability of the same methods in the other contexts and enhance the replicability of the research.

The final sub-question of this research focus on how the different qualities of the vegetation configurations impact on the levels of sense of safety and comfort in urban green spaces. To answer this sub-question the researcher carried out a stepwise regression with the objective data collected (attribute related data for the selected cases in the selected case study location of Vihara Maha Devi Park) along with the subjective data collected on site and online. The subjective data were collected with the developed self-assessment tool in the first phase of the study. The final results of the regression analysis showed that the view depth, visual permeability and degree of enclosure impact positively on both the sense of safety and comfort. These means that the increase of these qualities will increase the sense of safety and comfort. The more you can see from a location is better for you to feel safer and comfortable. With the objective data obtained with the selected locations at Vihara Maha Devi Park, the users prefer at least 33% (approximately) of the visual frame to be enclosed from the others and the rest should be open up to 80% (approximately). Similarly, the increase of the visibility of yourself to the other users (degree of exposure) also increases the levels of sense of comfort. These findings says that any space in an urban green space should allow visual links from and towards the users. Both the individuals and the other users of the space should be able to see each other while a considerable portion of the spaces should allow a level of privacy as well. Contrastingly, the increase in visual complexity will impact negatively on both the sense of safety and comfort. If the visual appeal of the surroundings is more complex and chaotic, then users are not comfortable in such spaces. The spaces at an urban green space should not be visually complex. If there are spaces where extreme level of movements and activities are expected, then the elements of such spaces should be maintained to not be disordered. Also, users tend to dislike a space when there is increased accessibility to space as they feel such spaces as threatening and deemed uncomfortable for use. If a space is easily accessible, then it shows that such spaces can be accessible for any threats as well. Furthermore, the findings showed that an increase in a scale's height to width ratio has a negative effect on users' feelings of comfort and safety. It has been demonstrated that users favor low relative scale areas that have low heights and longer horizontal separations between neighbouring objects. These findings demonstrate that different vegetation configurations have different effects on users' feelings of comfort and safety, achieving the final research objective (5) evaluating the impact of vegetation configurations on the sense of safety and comfort in urban green spaces. Based on the findings in the final section of the study, the following recommendations can be done on developing/ modifying the urban green spaces.

- The spaces may allow a certain level of privacy with the use of enclosure
- The spaces may allow visual links to the surrounding spaces. Deeper the visual links better for the safer and comfortable use
- It is better if the other users of the space can clearly see you
- Better to refrain from disorderly vegetation elements if the spaces are intended for complex activities
- The spaces may have limited accessibility
- More sky visibility is preferred at a space
- The spaces may be open with low heights and longer horizontal distances

The study is done focusing the context of Sri Lanka with the considerations on the climate and the contextual uniqueness of the country. In research focusing on the psychological aspects, it is hard to exclude the subjectivity of the respondents. So, in each process where user inputs (both expert and public) are used, there might be an impact from the subjectivity. The selected urban park has its own merits and demerits as this park was selected since it is the mostly used urban park which is covered by a highly urban context. Replication of the self-assessment tool might need re-evaluation from a group of experts as the variables might differ according to the contextual, cultural and other differences. All the objective methods of analysing the qualities of the vegetation can be directly replicated based on the selected cases. The results might provide you with better insights if the sample is increased. Proper data replicated to this model (phase one and phase two combined) can provide you with better insights into the factors which should be looked at when designing or modifying urban green environments for the users.

5.1 Limitations of the Study

This study offers significant contributions to the understanding of how vegetation configurations in urban green spaces influence psychological constructs of safety and comfort. However, several limitations must be acknowledged to contextualize the findings accurately.

Primarily, the research was geographically confined to a selected single urban green space, Vihara Maha Devi Park in Colombo, Sri Lanka, which may limit the applicability of the results to other regions with different climatic, cultural, and socio-economic conditions. The speciality of the context means that the findings might not be directly transferable to urban green spaces in different countries, especially those outside of tropical climates. Also, this study has focussed on daytime features of vegetation configurations. Nighttime analysis was not included in this study due to the absence of suitable cases with adequate lighting that effectively represents the vegetation qualities and features during the night. Nighttime visibility, lighting, and how vegetation interacts with these factors could yield different insights, thus presenting a gap in the current research. Additionally, the study's methodological approach, which involved both conventional and simulation-based analysis methods, was constrained by the available resources and technological capabilities in Sri Lanka. While the study aimed to blend traditional observation techniques with modern simulation tools, the technological limitations might have influenced the comprehensiveness and precision of the analysis. The range of vegetation qualities studied was also restricted to those present in the existing spaces of the selected case study, with no effort made to artificially manipulate or expand these qualities. As a result, the findings reflect only a subset of possible vegetation configurations and their impacts, which may not cover the full spectrum of urban green space designs. Furthermore, the study's reliance on subjective user input introduces the unavoidable limitation of personal bias and variability in perceptions. Although the sample size was increased to mitigate this, individual differences in background, experience, and cultural context were not controlled for, which could influence the generalizability of the results.

5.2 Future Recommendations

The findings of this research open several directions for future studies that could deepen or surpass the understanding of how urban green spaces can be designed to enhance psychological constructs of safety and comfort. To build upon the current study, the following future directions and recommendations are proposed.

- Future research should consider replicating this study across multiple urban parks in diverse climatic and cultural settings. By including green spaces in temperate, arid, or cold climates, researchers could compare the impact of vegetation configurations across different environments, providing a broader, more globally applicable understanding of how greenery affects sense of safety and comfort.
- The exclusion of nighttime features represents a significant limitation that future studies should address. Research that includes the effects of lighting, nighttime visibility, and the interplay between vegetation and artificial light could offer more comprehensive insights into how urban green spaces function around the clock, especially in terms of safety and comfort.
- The current study focused on a limited set of vegetation qualities due to the constraints of the existing selected urban park setup. Future research could expand this by using experimental setups, such as mock environments or digital simulations, to explore a wider range of vegetation configurations. This could help identify optimal designs for enhancing safety and comfort in urban green spaces.
- Developing the self-assessment tool into a digital application or software would significantly enhance its utility. Such a tool could be integrated with mobile technology to allow real-time data collection and analysis, making it more accessible and user-friendly. Additionally, incorporating AI-driven analysis and predictive modelling could provide urban planners and designers with more accurate tools for predicting the impact of vegetation configurations on user perceptions.
- Future studies could delve deeper into how social, cultural, and demographic factors influence perceptions of safety and comfort in urban green spaces. Understanding these variables could lead to the design of more inclusive and culturally sensitive public spaces, ensuring that urban parks meet the needs of all users, regardless of their background.
- Conducting longitudinal studies could provide insights into how changes in vegetation over time, such as growth, seasonal changes, or intentional

modifications, impact user perceptions. This would help in understanding the long-term effects of vegetation configurations and inform strategies for sustainable urban green space management.

- Future research could also explore how emerging technologies, such as augmented reality (AR) or virtual reality (VR), could be used to simulate different vegetation configurations and gather user feedback in a controlled environment before actual implementation. This could serve as a cost-effective way to test and refine urban park designs.
- Fostering interdisciplinary collaboration between urban planners, landscape architects, environmental psychologists, and technology experts could lead to innovative approaches in the study and design of urban green spaces. Collaborative research could integrate diverse perspectives and expertise, leading to more holistic and effective urban green space solutions.

By addressing these areas in future research, we can continue to enhance our understanding of how urban green spaces contribute to psychological safety and comfort, ultimately leading to the creation of safer, more comfortable, and more inclusive public spaces for all.

REFERENCES

Abas, M. A., & Broadhead, J. C. (1997). Depression and anxiety among women in an urban setting in Zimbabwe. *Psychological Medicine*, *27*(1), 59–71. https://doi.org/10.1017/S0033291796004163

Abrams, D., Christian, J., & Gordon, D. (2008). *Multidisciplinary Handbook of Social Exclusion Research*. John Wiley & Sons.

Anderson, L. M., & Stokes, G. S. (1989). Planting in parking lots to improve perceived attractiveness and security. *Journal of Arboriculture (USA)*. https://agris.fao.org/agris-search/search.do?recordID=US8904948

Andrews, K. (2019). Causes of Social Anxiety. *Bridges to Recovery*. https://www.bridgestorecovery.com/social-anxiety/causes-social-anxiety/

Andrews, M., & Gatersleben, B. (2010). Variations in perceptions of danger, fear and preference in a simulated natural environment. *Journal of Environmental Psychology*, *30*(4), 473–481. https://doi.org/10.1016/j.jenvp.2010.04.001

Appleton, J. (1975). *The Experience of Landscape*. Wiley.

Appleton, J. (1984). Prospects and Refuges Re-Visited. *Landscape Journal*, *3*(2), 91–103. JSTOR.

Askari, A. H., & Soltani, S. (2019). Determinants of a successful public open space: The case of Dataran Merdeka in the city centre of Kuala Lumpur, Malaysia. *Landscape Research*, *44*(2), 162–173. https://doi.org/10.1080/01426397.2018.1427221

Aung, A. M. N. (2020). Relationship between enclosure ratio and emotional experience on Shwedagon complex. *International Journal for Innovative Research in Multidisciplinary Field*, *6*(1).

Austin, D. M., Furr, L. A., & Spine, M. (2002). The effects of neighborhood conditions on perceptions of safety. *Journal of Criminal Justice*, *30*(5), 417–427. https://doi.org/10.1016/S0047-2352(02)00148-4

Baran, P. K., Tabrizian, P., Zhai, Y., Smith, J. W., & Floyd, M. F. (2018). An exploratory study of perceived safety in a neighborhood park using immersive virtual environments. *Urban Forestry & Urban Greening*, *35*, 72–81. https://doi.org/10.1016/j.ufug.2018.08.009

Batty, M. (2001). Exploring Isovist Fields: Space and Shape in Architectural and Urban Morphology. *Environment and Planning B: Planning and Design*, *28*, 123–150. https://doi.org/10.1068/b2725

Beaumont, R. (2012). *An introduction to Principal Component Analysis & Factor Analysis Using SPSS 19 and R* (p. 24).

Behrens, R. R. (1998). Art, Design and Gestalt Theory. *Leonardo, 31*(4), 299–303.

Bennetts, H., Soebarto, V., Oakley, S., & Babie, P. (2017). Feeling safe and comfortable in the urban environment. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 1–21. https://doi.org/10.1080/17549175.2017.1310746

Berg, R. G. van den. (2018). *SPSS Stepwise Regression—Simple Tutorial*. https://www.spss-tutorials.com/stepwise-regression-in-spss-example/

Berlyne, D. E. (1974). *Studies in the new experimental aesthetics: Steps toward an objective psychology of aesthetic appreciation* (pp. viii, 340). Hemisphere.

Björklund, M. (2019). Be careful with your principal components. *Evolution*, *73*(10), 2151–2158. https://doi.org/10.1111/evo.13835

Blöbaum, A., & Hunecke, M. (2005). Perceived Danger in Urban Public Space: The Impacts of Physical Features and Personal Factors. *Environment and Behavior, 37*(4), 465–486. https://doi.org/10.1177/0013916504269643

Blöbaum, A., & Hunecke, M. (2016). Perceived Danger in Urban Public Space: The Impacts of Physical Features and Personal Factors. *Environment and Behavior*. https://doi.org/10.1177/0013916504269643

Boström, M., Ernsth Bravell, M., Lundgren, D., & Björklund, A. (2013). Promoting sense of security in old-Age care. *Health*, *05*, 56–63. https://doi.org/10.4236/health.2013.56A2009

Burgess, J., Harrison, C. M., & Limb, M. (1988). People, Parks and the Urban Green: A Study of Popular Meanings and Values for Open Spaces in the City. *Urban Studies*, *25*(6), 455–473. https://doi.org/10.1080/00420988820080631

Bustamante, N. (2022). *What is Gestalt Psychology? Definition, Principles, & Examples*. https://www.simplypsychology.org/what-is-gestalt-psychology.html

Caballero, M. J., & Pride, W. M. (1984). Selected effects of salesperson sex and attractiveness in direct mail advertisements. *Journal of Marketing*, *48*(1), 94–100. https://doi.org/10.2307/1251315

Caldera, A., & Perera, N. (2018). *Influence of Tree Shade Level on Comfort Perception—A Case Study of Outdoor Public Spaces of Viharamahadevi Park, Colombo*.

Carmona, M. (2021). *Public Places Urban Spaces: The Dimensions of Urban Design* (3rd ed.). Routledge. https://doi.org/10.4324/9781315158457

Carmona, M., Heath, T., Oc, T., & Tiesdell, S. (2010). *Public Places Urban Spaces, Second Edition: The Dimensions of Urban Design* (2 edition). Architectural Press.

Carter, P. (2002). *Repressed spaces: The poetics of agoraphobia*. Reaktion Books. http://dro.deakin.edu.au/view/DU:30023978

Castle, J. L., Doornik, J. A., & Hendry, D. F. (2011). Evaluating Automatic Model Selection. *Journal of Time Series Econometrics*, *3*(1). https://doi.org/10.2202/1941-1928.1097

Chen, T., Lang, W., & Li, X. (2020). Exploring the Impact of Urban Green Space on Residents' Health in Guangzhou, China. *Journal of Urban Planning and Development*, *146*(1), 05019022. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000541

Chen, W.-Y. (2013). *NeuroInvesting: Build a New Investing Brain*. Hoboken : Wiley.

Chiang, Y. C., Nasar, J. L., & ChiaChun, K. (2014). Influence of visibility and situational threats on forest trail evaluations. *Landscape and Urban Planning*, *125,* 166–173.

Cobbina, J. E., Miller, J., & Brunson, R. K. (2008). Gender, neighborhood danger, and risk-avoidance strategies among urban african-american youths*. *Criminology*, *46*(3), 673–709. https://doi.org/10.1111/j.1745-9125.2008.00122.x

Cottet, M., Vaudor, L., Tronchère, H., Roux-Michollet, D., Augendre, M., & Brault, V. (2018). Using gaze behavior to gain insights into the impacts of naturalness on city dwellers' perceptions and valuation of a landscape. *Journal of Environmental Psychology*, *60*, 9–20. https://doi.org/10.1016/j.jenvp.2018.09.001

Davis, M. (1999). *Ecology of Fear: Los Angeles and the Imagination of Disaster* (1st Vintage Books ed edition). Vintage.

De Lucio, J. V., Mohamadian, M., Ruiz, J. P., Banayas, J., & Bernaldez, F. G. (1996). Visual landscape exploration as revealed by eye movement tracking. *Landscape and Urban Planning*, *34*(2), 135–142. https://doi.org/10.1016/0169-2046(95)00208-1

Dee, C. (2001). *Form and Fabric in Landscape Architecture: A Visual Introduction*. Taylor & Francis.

Dillon, R. (2005). Designing urban space for psychological comfort: The Kentish Town Road project. *Journal of Public Mental Health*, *4*(4), 10–20. https://doi.org/10.1108/17465729200500027

Dogrusoy, I. T., & Zengel, R. (2017). Analysis Of Perceived Safety In Urban Parks: A Field Study In Büyükpark And Hasanağa Park. *METU Journal of the Faculty of Architecture*, *34*. https://doi.org/10.4305/METU.JFA.2017.1.7

Donovan, G. H., & Prestemon, J. P. (2012). The Effect of Trees on Crime in Portland, Oregon. *Environment and Behavior*, *44*(1), 3–30. https://doi.org/10.1177/0013916510383238

Dosen, A., & Ostwald, M. (2013). Prospect and refuge theory: Constructing a critical definition for architecture and design. *International Journal of Design in Society*, *6*, 9–23. https://doi.org/10.18848/2325-1328/CGP/v06i01/38559

Dubois, A., & Gadde, L.-E. (2002). Systematic Combining: An Abductive Approach to Case Research. *Journal of Business Research*, *55*, 553–560. https://doi.org/10.1016/S0148-2963(00)00195-8

Dupont, L., Antrop, M., & Van Eetvelde, V. (2014). Eye-tracking Analysis in Landscape Perception Research: Influence of Photograph Properties and Landscape Characteristics. *Landscape Research*, *39*(4), 417–432. https://doi.org/10.1080/01426397.2013.773966

Dupont, L., Ooms, K., Duchowski, A. T., Antrop, M., & Van Eetvelde, V. (2017). Investigating the visual exploration of the rural-urban gradient using eye-tracking. *Spatial Cognition & Computation*, *17*(1–2), 65–88. https://doi.org/10.1080/13875868.2016.1226837

Dzhambov, A. M., & Dimitrova, D. D. (2014). Elderly visitors of an urban park, health anxiety and individual awareness of nature experiences. *Urban Forestry & Urban Greening*, *13*(4), 806–813. https://doi.org/10.1016/j.ufug.2014.05.006

Ewing, R., & Handy, S. (2009). Measuring the Unmeasurable: Urban Design Qualities Related to Walkability. *Journal of Urban Design*, *14*(1), 65–84. https://doi.org/10.1080/13574800802451155

Fisher, B. S., & May, D. (2009). College Students' Crime-Related Fears on Campus: Are Fear-Provoking Cues Gendered? *Journal of Contemporary Criminal Justice*. https://doi.org/10.1177/1043986209335013

Fisher, B. S., & Nasar, J. L. (1992). Fear of Crime in Relation to Three Exterior Site Features: Prospect, Refuge, and Escape. *Environment and Behavior*. https://doi.org/10.1177/0013916592241002

Foltête, J.-C., Ingensand, J., & Blanc, N. (2020). Coupling crowd-sourced imagery and visibility modelling to identify landscape preferences at the panorama level. *Landscape and Urban Planning*, *197*, 103756. https://doi.org/10.1016/j.landurbplan.2020.103756

Force, G. B. U. T., Rogers, R. G., Great Britain. Dept. of the Environment, T., & Force, the R. U. T. (1999). *Towards an urban renaissance*. [London : Spon]. https://trove.nla.gov.au/version/44418173

Fox, K. A., Nobles, M. R., & Piquero, A. R. (2009). Gender, crime victimization and fear of crime. *Security Journal*, *22*(1), 24–39. https://doi.org/10.1057/sj.2008.13

Francis, M. (2009). Convivial Urban Spaces: Creating Effective Public Places Henry Shaftoe. *Journal of Urban Design*, *14*(3), 404–405.

Gabbiani, F., & Cox, S. J. (2017). Chapter 22—Firing Rate Codes and Early Vision. In F. Gabbiani & S. J. Cox (Eds.), *Mathematics for Neuroscientists (Second Edition)* (pp. 383–394). Academic Press. https://doi.org/10.1016/B978-0-12-801895-8.00022-1

Gilchrist, E., Bannister, J., Ditton, J., & Farrall, S. (1998). Women and the "Fear of Crime": Challenging the Accepted Stereotype. *The British Journal of Criminology*, *38*(2), 283–298.

Gilstad-Hayden, K., Wallace, L., Carroll-Scott, A., Meyer, S., Barbo, S., Murphy-Dunning, C., & Ickovics, J. (2015). Research note: Greater tree canopy cover is associated with lower rates of both violent and property crime in New Haven, CT. *Landscape and Urban Planning*, *In press*. https://doi.org/10.1016/j.landurbplan.2015.08.005

Green, G., Gilbertson, J., & Grimsley, M. (2002). Fear of crime and health in residential tower blocks. A case study in Liverpool, UK. *European Journal of Public Health*, *12*, 10–15.

Haile, C. (2019, April 18). *A Myth of Urban Design: The 'Sense of Enclosure' Theory | Chris Haile*. https://www.chrishaile.com/a-myth-of-urban-design-the-sense-of-enclosure-theory/

Haldun Muderrisoglu, & Zeki Demir. (2004). The Relationship Between Perceived Beauty and Safety in Urban Recreation Parks. *Journal of Applied Sciences*, *4*(1), 72–77.

Han, K.-T. (2003). A reliable and valid self-rating measure of the restorative quality of natural environments. *Landscape and Urban Planning*, *64*, 209–232. https://doi.org/10.1016/S0169-2046(02)00241-4

Han, S., Love, P., & Peña-Mora, F. (2013). A system dynamics model for assessing the impacts of design errors in construction projects. *Mathematical and Computer Modelling*, *57*(9), 2044–2053. https://doi.org/10.1016/j.mcm.2011.06.039

Harrell, F. E. (2001). *Regression Modeling Strategies: With Applications to Linear Models, Logistic Regression, and Survival Analysis*. Springer. https://doi.org/10.1007/978-1-4757-3462-1

Hartig, T., Korpela, K., Evans, G. W., & Gärling, T. (1997). A measure of restorative quality in environments. *Scandinavian Housing and Planning Research*, *14*(4), 175–194. https://doi.org/10.1080/02815739708730435

Hartig, T., Mang, M., & Evans, G. W. (1991). Restorative Effects of Natural Environment Experiences: *Environment and Behavior*. https://doi.org/10.1177/0013916591231001

Hartig, T., & Staats, H. (2006a). The need for psychological restoration as a determinant of environmental preferences. *Journal of Environmental Psychology*, *26*, 215–226. https://doi.org/10.1016/j.jenvp.2006.07.007

Hartig, T., & Staats, H. (2006b). The need for psychological restoration as a determinant of environmental preferences. *Journal of Environmental Psychology*, *26*, 215–226. https://doi.org/10.1016/j.jenvp.2006.07.007

Harvey, C., Aultman-Hall, L., Hurley, S., & Troy, A. (2015). Effects of skeletal streetscape design on perceived safety. *Landscape and Urban Planning*, *142*. https://doi.org/10.1016/j.landurbplan.2015.05.007

Hashim, N. H. M., Thani, S. K. S. O., Jamaludin, M. A., & Yatim, N. M. (2016). A Perceptual Study on the Influence of Vegetation Design Towards Women's Safety in Public Park. *Procedia - Social and Behavioral Sciences, 234*, 280–288. https://doi.org/10.1016/j.sbspro.2016.10.244

Henderson, J. M., Brockmole, J. R., Castelhano, M. S., & Mack, M. (2007). Chapter 25—Visual saliency does not account for eye movements during visual search in real-world scenes. In R. P. G. Van Gompel, M. H. Fischer, W. S. Murray, & R. L. Hill (Eds.), *Eye Movements* (pp. 537–III). Elsevier. https://doi.org/10.1016/B978-008044980-7/50027-6

Herzog, T., & Chernick, K. (2000). Tranquility and danger in urban and natural settings. *Journal of Environmental Psychology, 20*, 29–39. https://doi.org/10.1006/jevp.1999.0151

Herzog, T. R., & Bryce, A. G. (2007). Mystery and Preference in Within-Forest Settings. *Environment and Behavior*, *39*(6), 779–796. https://doi.org/10.1177/0013916506298796

Herzog, T. R., & Kropscott, L. S. (2004). Legibility, Mystery, and Visual Access as Predictors of Preference and Perceived Danger in Forest Settings without Pathways. *Environment and Behavior*, *36*(5), 659–677. https://doi.org/10.1177/0013916504264138

Herzog, T. R., & Kutzli, G. E. (2002). Preference and Perceived Danger in Field/Forest Settings. *Environment and Behavior*, *34*(6), 819–835. https://doi.org/10.1177/001391602237250

Hollander, J. B., Sussman, A., Lowitt, P., Angus, N., & Situ, M. (2021). Eye-tracking emulation software: A promising urban design tool. *Architectural Science Review*, *64*(4), 383–393. https://doi.org/10.1080/00038628.2021.1929055

Hollander, J. B., Sussman, A., Purdy Levering, A., & Foster-Karim, C. (2020). Using Eye-Tracking to Understand Human Responses to Traditional Neighborhood Designs.

Planning Practice & Research, *35*(5), 485–509. https://doi.org/10.1080/02697459.2020.1768332

Hung, K., & Crompton, J. L. (2006). Benefits and Constraints Associated with the Use of an Urban Park Reported by a Sample of Elderly in Hong Kong. *Leisure Studies*, *25*(3), 291–311. https://doi.org/10.1080/02614360500409810

Hunter, M., & Askarinejad, A. (2015). Designer's approach for scene selection in tests of preference and restoration along a continuum of natural to manmade environments. *Frontiers in Psychology*, *6*, 1228. https://doi.org/10.3389/fpsyg.2015.01228

Hussain, D., & Imitiyaz, I. (2018). *Urbanization concepts, Dimensions and factors*. *9*, 23513–23523.

Imre, A., & Bogaert, J. (2004). The Fractal Dimension as a Measure of the Quality of Habitats. *Acta Biotheoretica*, *52*, 41–56. https://doi.org/10.1023/B:ACBI.0000015911.56850.0f

Itti, L., & Koch, C. (2001). Computational modelling of visual attention. *Nature Reviews Neuroscience*, *2*(3), Article 3. https://doi.org/10.1038/35058500

Jackson, J., & Stafford, M. (2009). Public Health and Fear of Crime: A Prospective Cohort Study. *British Journal of Criminology - BRIT J CRIMINOL*, *49*. https://doi.org/10.1093/bjc/azp033

Jacobs, J. (1961). *The death and life of great American cities*.

Jansson, M., Fors, H., Lindgren, T., & Wiström, B. (2013). Perceived personal safety in relation to urban woodland vegetation – A review. *Urban Forestry & Urban Greening*, *12*(2), 127–133. https://doi.org/10.1016/j.ufug.2013.01.005

Jiang, B., Li, D., Larsen, L., & Sullivan, W. (2014). A Dose-Response Curve Describing the Relationship Between Urban Tree Cover Density and Self-Reported Stress Recovery. *Environment and Behavior*, *48*. https://doi.org/10.1177/0013916514552321

Jiang, S., & Liu, D. (2012). Box-Counting Dimension of Fractal Urban Form: Stability Issues and Measurement Design. *International Journal of Artificial Life Research*, *3*(3), 41–63. https://doi.org/10.4018/jalr.2012070104

Jorgensen, A., Hitchmough, J., & Calvert, T. (2002). Woodland spaces and edges: Their impact on perception of safety and preference. *Landscape and Urban Planning*, *60*(3), 135–150. https://doi.org/10.1016/S0169-2046(02)00052-X

Jorgensen, A., Hitchmough, J., & Dunnett, N. (2007). Woodland as a setting for housing-appreciation and fear and the contribution to residential satisfaction and place identity in Warrington New Town, UK. *Landscape and Urban Planning*, *79*(3), 273–287. https://doi.org/10.1016/j.landurbplan.2006.02.015

Jorgensen, L., Ellis, G. D., & Ruddell, E. (2013). Fear Perceptions in Public Parks Interactions of Environmental Concealment, the Presence of People Recreating, and Gender. *Environment and Behavior*, *45*, 803–820. https://doi.org/10.1177/0013916512446334

Kapferer, J.-N. (1992). *The New Strategic Brand Management*. the free press.

Kaplan, R., & Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. CUP Archive.

Kaplan, S. (1987). Aesthetics, Affect, and Cognition: Environmental Preference from an Evolutionary Perspective. *Environment and Behavior*, *19*(1), 3–32. https://doi.org/10.1177/0013916587191001

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*(3), 169–182. https://doi.org/10.1016/0272-4944(95)90001-2

Karmanov, D. Y. (2009). *Feeling the landscape: Six psychological studies into landscape experience*. Wageningen University.

Karperien, A. (2007). *FracLac for ImageJ* (Version 2.5) [ImageJ]. https://imagej.nih.gov/ij/plugins/fraclac/FLHelp/Introduction.htm

Kawshalya, L., & Dharmasena, J. (2019). To See Without Being Seen: Landscape perception and human behaviour in urban parks. *Cities People Places : An International Journal on Urban Environments*, *4*, 1. https://doi.org/10.4038/cpp.v4i1.40

Kawshalya, L. W. G., Weerasinghe, U. G. D., & Chandrasekara, D. P. (2022). The impact of visual complexity on perceived safety and comfort of the users: A study on urban streetscape of Sri Lanka. *PLOS ONE*, *17*(8), e0272074. https://doi.org/10.1371/journal.pone.0272074

Kawshalya, L., Weerasinghe, U., & Chandrasekara, D. (2020). Fear of Crime in Urban Environments: A Bibliometric Mapping of the Literature. *2020 From Innovation to Impact (FITI)*, *1*, 1–6. https://doi.org/10.1109/FITI52050.2020.9424901

Kaymaz, I. C. (2012). Landscape Perception. *Landscape Planning*. https://doi.org/10.5772/38998

Kelemen, M. L., & Rumens, N. (2008). *An Introduction to Critical Management Research*. SAGE.

Kim, J. (2017). Comparing the Influences of the D/H Ratio, Size, and Facade Design of an Enclosed Square on Its Perceptual Qualities as a Sustainable Urban Space in South Korea. *Sustainability*, *9*, 675. https://doi.org/10.3390/su9040675

Kim, J., & Kim, S. (2019). Finding the Optimal D/H Ratio for an Enclosed Urban Square: Testing an Urban Design Principle Using Immersive Virtual Reality Simulation Techniques. *International Journal of Environmental Research and Public Health, 16*(5), 865. https://doi.org/10.3390/ijerph16050865

Klemm, W., Heusinkveld, B. G., Lenzholzer, S., Jacobs, M. H., & Van Hove, B. (2015). Psychological and physical impact of urban green spaces on outdoor thermal comfort during summertime in The Netherlands. *Building and Environment*, *83*, 120–128. https://doi.org/10.1016/j.buildenv.2014.05.013

Koskela, H., & Pain, R. (2000). Revisiting fear and place: Women's fear of attack and the built environment. *Geoforum*, *31*(2), 269–280. https://doi.org/10.1016/S0016-7185(99)00033-0

Kuo, F. E., & Sullivan, W. C. (2001). Environment and Crime in the Inner City: Does Vegetation Reduce Crime? *Environment and Behavior*, *33*(3), 343–367. https://doi.org/10.1177/0013916501333002

Kuo, F. E., Sullivan, W. C., Coley, R. L., & Brunson, L. (1998). Fertile Ground for Community: Inner-City Neighborhood Common Spaces. *American Journal of Community Psychology*, *26*(6), 823–851. https://doi.org/10.1023/A:1022294028903

Kweon, B.-S., Sullivan, W. C., & Wiley, A. R. (2016a). Green Common Spaces and the Social Integration of Inner-City Older Adults: *Environment and Behavior*. https://doi.org/10.1177/001391659803000605

Kweon, B.-S., Sullivan, W. C., & Wiley, A. R. (2016b). Green Common Spaces and the Social Integration of Inner-City Older Adults: *Environment and Behavior*. https://doi.org/10.1177/001391659803000605

Lavdas, A. A., Salingaros, N. A., & Sussman, A. (2021). Visual Attention Software: A New Tool for Understanding the "Subliminal" Experience of the Built Environment. *Applied Sciences*, *11*(13), Article 13. https://doi.org/10.3390/app11136197

Lehto, X. (2013). Assessing the Perceived Restorative Qualities of Vacation Destinations. *Journal of Travel Research, 52,* 325–339. https://doi.org/10.1177/0047287512461567

Li, X., Zhang, C., & Li, W. (2015). Does the Visibility of Greenery Increase Perceived Safety in Urban Areas? Evidence from the Place Pulse 1.0 Dataset. *ISPRS International Journal of Geo-Information*, *4*, 1166–1183. https://doi.org/10.3390/ijgi4031166

Li, Z., & Yin, Y. (2018). Attractiveness, expertise and closeness: The effect of source credibility of the first lady as political endorser on social media in China. *Global Media and China*, *3*(4), 297–315. https://doi.org/10.1177/2059436418819228

Lis, A., & Iwankowski, P. (2021). Why is dense vegetation in city parks unpopular? The mediative role of sense of privacy and safety. *Urban Forestry & Urban Greening*, *59*, 126988. https://doi.org/10.1016/j.ufug.2021.126988

Lis, A., Krzemińska, A., Dzikowska, A., & Zalewska, K. J. (2014). *Spatial determinants of safety in a city park as exemplified by Jan III Sobieski Park in Wałbrzych (Poland)*.

Lis, A., Pardela, Ł., & Iwankowski, P. (2019a). Impact of Vegetation on Perceived Safety and Preference in City Parks. *Sustainability*, *11*(22), Article 22. https://doi.org/10.3390/su11226324

Lis, A., Pardela, L., & Iwankowski, P. (2019b). Impact of Vegetation on Perceived Safety and Preference in City Parks. *Sustainability*, *11*. https://doi.org/10.3390/su11226324

Liu, L. (2020). Emerging study on the transmission of the Novel Coronavirus (COVID-19) from urban perspective: Evidence from China. *Cities*, *103*, 102759. https://doi.org/10.1016/j.cities.2020.102759

Liu, Q., Zhu, Z., Zeng, X., Zhuo, Z., Ye, B., Fang, L., Huang, Q., & Lai, P. (2021). The impact of landscape complexity on preference ratings and eye fixation of various urban green space settings. *Urban Forestry & Urban Greening*, *66*, 127411. https://doi.org/10.1016/j.ufug.2021.127411

Liu, Y., Hu, M., & Zhao, B. (2019). Audio-visual interactive evaluation of the forest landscape based on eye-tracking experiments. *Urban Forestry & Urban Greening*, *46*, 126476. https://doi.org/10.1016/j.ufug.2019.126476

Lopes, M., Santos Cruz, S., & Pinho, P. (2019). Revisiting Publicness in Assessment of Contemporary Urban Spaces. *Journal of Urban Planning and Development*, *145*(4), 04019013. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000521

Lu, Y., & Tang, J. (2004). Fractal Dimension of a Transportation Network and its Relationship with Urban Growth: A Study of the Dallas-Fort Worth Area. *Environment and Planning B: Planning and Design*, *31*, 895–911. https://doi.org/10.1068/b3163

Maas, J., Spreeuwenberg, P., Winsum-Westra, M. van, Verheij, R. A., Vries, S., & Groenewegen, P. P. (2009). Is Green Space in the Living Environment Associated with People's Feelings of Social Safety?: *Environment and Planning A*. https://doi.org/10.1068/a4196

Maas, J., Verheij, R. A., Groenewegen, P. P., Vries, S. de, & Spreeuwenberg, P. (2006). Green space, urbanity, and health: How strong is the relation? *Journal of Epidemiology & Community Health*, *60*(7), 587–592. https://doi.org/10.1136/jech.2005.043125

Madge, C. (1997). Public Parks and the Geography of Fear. *Tijdschrift Voor Economische En Sociale Geografie*, *88*(3), 237–250. https://doi.org/10.1111/j.1467-9663.1997.tb01601.x

Mahrous, A. M., Moustafa, Y. M., & Abou El-Ela, M. A. (2018). Physical characteristics and perceived security in urban parks: Investigation in the Egyptian context. *Ain Shams Engineering Journal*, *9*(4), 3055–3066. https://doi.org/10.1016/j.asej.2018.07.003

Mak, B. K. L., & Jim, C. Y. (2017). Examining fear-evoking factors in urban parks in Hong Kong. *Landscape and Urban Planning*, *171*, 42–56. https://doi.org/10.1016/j.landurbplan.2017.11.012

Mambretti, I. M. (2011). *Urban Parks Between Safety and Aesthetics: Exploring Urban Green Space Using Visualisation and Conjoint Analysis Methods*. vdf Hochschulverlag AG.

Mandelbrot, B. (1967). How long is the coast of Britain? Statistical self-similarity and fractional dimension. *Science*, *156*(3775), 636–638.

Mandelbrot, B. B. (1982). *The Fractal Geometry of Nature*.

Maruthaveeran, S., & van den Bosh, C. K. (2015). Fear of crime in urban parks–what the residents of kuala lumpur have to say? *Urban Forestry & Urban Greening*, *14*(3), 702–713.

Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., & Dolliver, K. (2008). Why Is Nature Beneficial?: The Role of Connectedness to Nature. *Environment and Behavior*. https://doi.org/10.1177/0013916508319745

Mehta, V. (2014). Evaluating Public Space. *Journal of Urban Design*, *19*(1), 53–88. https://doi.org/10.1080/13574809.2013.854698

Memari, S., & Pazhouhanfar, M. (2018). *Role of Kaplan's Preference Matrix in the Assessment of Building façade, Case of Gorgan, Iran*.

Morgan, A. J., Ross, A., & Reavley, N. J. (2018). Systematic review and meta-analysis of Mental Health First Aid training: Effects on knowledge, stigma, and helping behaviour. *PLOS ONE*, *13*(5), e0197102. https://doi.org/10.1371/journal.pone.0197102

Morton, L., Cogan, N., Kolacz, J., Calderwood, C., Nikolic, M., Bacon, T., Pathe, E., Williams, D., & Porges, S. W. (2022). A new measure of feeling safe: Developing psychometric properties of the Neuroception of Psychological Safety Scale (NPSS). *Psychological Trauma: Theory, Research, Practice and Policy*. https://doi.org/10.1037/tra0001313

Mouratidis, K. (2019). The impact of urban tree cover on perceived safety. *Urban Forestry & Urban Greening*, *44*, 126434. https://doi.org/10.1016/j.ufug.2019.126434

Muderrisoglu, H., & Demir, Z. (2004). The Relationship Between Perceived Beauty and Safety in Urban Recreation Parks. *Journal of Applied Sciences*, *4*. https://doi.org/10.3923/jas.2004.72.77

Müller, M. G., Kappas, A., & Olk, B. (2012). Perceiving press photography: A new integrative model, combining iconology with psychophysiological and eye-tracking methods. *Visual Communication*, *11*(3), 307–328. https://doi.org/10.1177/1470357212446410

Nasar, J. L. (1982). A model relating visual attributes in the residential environment to fear of crime,. *Journal of Environmental Systems*, *11*(3), 247–255. https://doi.org/10.2190/4EEQ-C09R-M4MX-JGA0

Nasar, J. L., & Fisher, B. (1993). “Hot spots” of fear and crime: A multi-method investigation. *Journal of Environmental Psychology*, *13*(3), 187–206. https://doi.org/10.1016/S0272-4944(05)80173-2

Nasar, J. L., Fisher, B., & Grannis, M. (1993). Proximate physical cues to fear of crime. *Landscape and Urban Planning*, *26*(1), 161–178. https://doi.org/10.1016/0169-2046(93)90014-5

Nasar, J. L., & Jones, K. M. (1997). Landscapes of Fear and Stress: *Environment and Behavior*. https://doi.org/10.1177/001391659702900301

Nayanathara, V., & Dharmasena, J. (2019). *Impact of Flora on Sense of Safety: A study of Independence Square, Colombo*.

O’Connor, Z. (2013). Colour, Contrast and Gestalt Theories of Perception: The Impact in Contemporary Visual Communications Design. *Color Research & Application*, *40*, 85–92. https://doi.org/10.1002/col.21858

Ode, Å., Hagerhall, C. M., & Sang, N. (2010). Analysing Visual Landscape Complexity: Theory and Application. *Landscape Research*, *35*(1), 111–131. https://doi.org/10.1080/01426390903414935

Ode Sang, Å., Tveit, M. S., Pihel, J., & Hägerhäll, C. M. (2016). Identifying cues for monitoring stewardship in Swedish pasture landscapes. *Land Use Policy*, *53*, 20–26. https://doi.org/10.1016/j.landusepol.2015.09.020

Özgüner, H. (2011). Cultural Differences in Attitudes towards Urban Parks and Green Spaces. *Landscape Research*, *36*(5), 599–620. https://doi.org/10.1080/01426397.2011.560474

Pain, R. H. (1997). Social Geographies of Women’s Fear of Crime. *Transactions of the Institute of British Geographers*, *22*(2), 231–244.

Pardela, L., Lis, A., Zalewska, K. J., & Iwankowski, P. (2022). How vegetation impacts preference, mystery and danger in fortifications and parks in urban areas.

Landscape and Urban Planning, *228*, 104558. https://doi.org/10.1016/j.landurbplan.2022.104558

Pasini, M., Berto, R., Brondino, M., Hall, R., & Ortner, C. (2014). How to Measure the Restorative Quality of Environments: The PRS-11. *Procedia - Social and Behavioral Sciences*, *159*, 293–297. https://doi.org/10.1016/j.sbspro.2014.12.375

Pineau, C. (1982). The psychological meaning of comfort. *Applied Psychology*, *31*(2), 271–282. https://doi.org/10.1111/j.1464-0597.1982.tb00097.x

Planning Officer - Vihara Mahadevi park. (2023, December 20). [Face to face].

Porges, S. W. (2003). The Polyvagal Theory: Phylogenetic contributions to social behavior. *Physiology & Behavior*, *79*(3), 503–513. https://doi.org/10.1016/S0031-9384(03)00156-2

Porges, S. W. (2009). The polyvagal theory: New insights into adaptive reactions of the autonomic nervous system. *Cleveland Clinic Journal of Medicine*, *76*(Suppl 2), S86–S90. https://doi.org/10.3949/ccjm.76.s2.17

Pun, V. C., Manjourides, J., & Suh, H. H. (2018). Association of neighborhood greenness with self-perceived stress, depression and anxiety symptoms in older U.S adults. *Environmental Health: A Global Access Science Source*, *17*(1), 39. https://doi.org/10.1186/s12940-018-0381-2

Qiu, W., Li, W., Zhang, Z., Li, X., Liu, X., & Huang, X. (2021). *Subjective and Objective Measures of Streetscape Perceptions: Relationships with Property Value in Shanghai*. https://doi.org/10.20944/preprints202103.0506.v1

Ramanujam, P. (2007). *Prospect-refuge theory revisited: A search for safety in dynamic public spaces with a reference to design*.

Ratnayake, R. (2017). Sense of safety in public spaces: University student safety experiences in an Australian regional city. *Rural Society*, *26*(1), 69–84. https://doi.org/10.1080/10371656.2017.1284616

Salesses, P., Schechtner, K., & Hidalgo, C. A. (2013). The Collaborative Image of The City: Mapping the Inequality of Urban Perception. *PLOS ONE*, *8*(7), e68400. https://doi.org/10.1371/journal.pone.0068400

Salingaros, N. A., & Sussman, A. (2020). Biometric Pilot-Studies Reveal the Arrangement and Shape of Windows on a Traditional Façade to be Implicitly "Engaging", Whereas Contemporary Façades are Not. *Urban Science*, *4*(2), Article 2. https://doi.org/10.3390/urbansci4020026

Sanyaolu, P., & Sanyaolu, C. O. (2018). Urbanization 1. *POLITICAL SCIENCE AND INTERNATIONAL RELATIONS*. https://doi.org/10.13140/RG.2.2.23495.96161

Sarkar, Md. S. K., Sadeka, S., Feardous, M. A. A., & Ahmed, S. (2013). Human Development Performance of Bangladesh: South Asian Perspective. *Journal of Applied Sciences Research*, *9*, 2475–2484.

Saunders, M. N. K., Lewis, P., & Thornhill, A. (2019). *Research Methods for Business Students*. Pearson.

Scarborough, B., Like-Haislip, T., Novak, K., Lucas, W., & Alarid, L. (2010). Assessing the Relationship Between Individual Characteristics, Neighborhood Context, and Fear of Crime. *Journal of Criminal Justice*, *38*, 819–826. https://doi.org/10.1016/j.jcrimjus.2010.05.010

Schirpke, U., Tasser, E., & Lavdas, A. A. (2022). Potential of eye-tracking simulation software for analyzing landscape preferences. *PLOS ONE*, *17*(10), e0273519. https://doi.org/10.1371/journal.pone.0273519

Schroeder, H. W. (1982). Preferred features of urban parks and forests. *Journal of Arboricuture 8(12):317-322*, *8*(12), Article 12. https://www.fs.usda.gov/treesearch/pubs/14854

Schroeder, H. W., & Anderson, L. M. (1984). Perception of personal safety in urban recreation sites. *Journal of Leisure Research 16(2):178-194*, *16*(2), Article 2. https://www.fs.usda.gov/treesearch/pubs/14855

Sepe, M. (2017). The Role of Public Space to Achieve Urban Happiness. *International Journal of Sustainable Development and Planning*, *12*(04), 724–733. https://doi.org/10.2495/SDP-V12-N4-724-733

Shaffer, G. S., & Anderson, L. M. (1985). Perceptions of the security and attractiveness of urban parking lots. *Journal of Environmental Psychology*, *5*(4), 311–323. https://doi.org/10.1016/S0272-4944(85)80001-3

Shaftoe, H. (2012). *Convivial Urban Spaces: Creating Effective Public Places*. Earthscan.

Sharma, K. (2012). *Celebrity endorsement and its impact on brand equity*. *3*(5), 14.

Shen, G. (2002). Fractal dimension and fractal growth of urbanized areas. *International Journal of Geographical Information Science*, *16*(5), 419–437. https://doi.org/10.1080/13658810210137013

Shepley, M., Sachs, N., Sadatsafavi, H., Fournier, C., & Peditto, K. (2019). The Impact of Green Space on Violent Crime in Urban Environments: An Evidence Synthesis. *International Journal of Environmental Research and Public Health*, *16*(24). https://doi.org/10.3390/ijerph16245119

Smardon, R. C. (1988). Perception and aesthetics of the urban environment: Review of the role of vegetation. *Landscape and Urban Planning*, *15*(1), 85–106. https://doi.org/10.1016/0169-2046(88)90018-7

Song, Z., Seitz, S., Zhu, P., Goebes, P., Shi, X., Xu, S., Wang, M., Schmidt, K., & Scholten, T. (2018). Spatial distribution of LAI and its relationship with throughfall kinetic energy of common tree species in a Chinese subtropical forest plantation. *Forest Ecology and Management*, *425*, 189–195. https://doi.org/10.1016/j.foreco.2018.05.046

Spellerberg, I. F., & Fedor, P. J. (2003). A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon–Wiener' Index. *Global Ecology and Biogeography*, *12*(3), 177–179. https://doi.org/10.1046/j.1466-822X.2003.00015.x

Stafford, M., Chandola, T., & Marmot, M. (2007). Association Between Fear of Crime and Mental Health and Physical Functioning. *American Journal of Public Health*, *97*(11), 2076–2081. https://doi.org/10.2105/AJPH.2006.097154

Stamps, A. E. (2003). Advances in Visual Diversity and Entropy. *Environment and Planning B: Planning and Design*, *30*(3), 449–463. https://doi.org/10.1068/b12986

Stamps, A. E. (2004). Mystery, complexity, legibility and coherence: A meta-analysis. *Journal of Environmental Psychology*, *24*(1), 1–16. https://doi.org/10.1016/S0272-4944(03)00023-9

Stamps, A. E. (2005). Isovists, Enclosure, and Permeability Theory. *Environment and Planning B: Planning and Design*, *32*(5), 735–762. https://doi.org/10.1068/b31138

Stamps, A. E. (2010a). Effects of Permeability on Perceived Enclosure and Spaciousness. *Environment and Behavior*, *42*(6), 864–886. https://doi.org/10.1177/0013916509337287

Stamps, A. E. (2010b). Use of Static and Dynamic Media to Simulate Environments: A Meta-Analysis. *Perceptual and Motor Skills*, *111*(2), 355–364. https://doi.org/10.2466/22.24.27.PMS.111.5.355-364

Stamps, A. E. (2011). Effects of Boundary Height and Horizontal Size within Boundary on Perceived Enclosure. *Perceptual and Motor Skills*, *113*(3), 995–998. https://doi.org/10.2466/24.27.PMS.113.6.995-998

Stamps, A. E. (2013). Effects of Multiple Boundaries on Perceived Spaciousness and Enclosure. *Environment and Behavior*, *45*(7), 851–875. https://doi.org/10.1177/0013916512446808

Sternberg, R. J., Sternberg, K., & Mio, J. S. (2012). *Cognitive psychology*. Wadsworth/Cengage Learning.

Stigsdotter, U. K., Ekholm, O., Schipperijn, J., Toftager, M., Kamper-Jørgensen, F., & Randrup, T. B. (2010). Health promoting outdoor environments—Associations between green space, and health, health-related quality of life and stress based on a

Danish national representative survey. *Scandinavian Journal of Public Health*, *38*(4), 411–417. https://doi.org/10.1177/1403494810367468

Suddaby, R. (2006). From the Editors: What Grounded Theory is Not. *Academy of Management Journal*, *49*(4), 633–642. https://doi.org/10.5465/amj.2006.22083020

Talbot, J. f, & Kaplan, R. (1984). Needs and fears: The response to trees and nature in the inner city [Urban forestry, Detroit, Michigan]. *Journal of Arboriculture*.

Talepasand, S., Haddadi, S., & Taghinezhad, A. (2016). *Satisfaction and Happiness as a Function of Parks Planning Satisfaction and Happiness as a Function of* (Health Education and Health Promotion). https://www.researchgate.net/publication/319310545_Satisfaction_and_Happiness_as_a_Function_of_Parks_Planning_Satisfaction_and_Happiness_as_a_Function_of

Tang, I. -chun, Sullivan, W. C., & Chang, C. (2015). Perceptual Evaluation of Natural Landscapes: The Role of the Individual Connection to Nature. *Environment and Behavior*, *47*(6), 595–617. https://doi.org/10.1177/0013916513520604

Tasser, E., Lavdas, A. A., & Schirpke, U. (2023). Assessing landscape aesthetic values: Do clouds in photographs influence people's preferences? *PLOS ONE*, *18*(7), e0288424. https://doi.org/10.1371/journal.pone.0288424

Troy, A., Morgan Grove, J., & O'Neil-Dunne, J. (2012). The relationship between tree canopy and crime rates across an urban–rural gradient in the greater Baltimore region. *Landscape and Urban Planning*, *106*(3), 262–270. https://doi.org/10.1016/j.landurbplan.2012.03.010

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., & Kagawa, T. (2014). *The in fl uence of urban green environments on stress relief measures: A fi eld experiment*. /paper/The-in-fl-uence-of-urban-green-environments-on-%3A-A-Tyrv%C3%A4inen-Ojala/26b834e99c010fafebb8a7859f3882e93986b3dc

UCLA. (2022). *Introduction to Regression with SPSS: SPSS Regression Diagnostics*. Statistical Methods and Data Analysis. https://stats.oarc.ucla.edu/spss/seminars/introduction-to-regression-with-spss/introreg-lesson2/

Ulrich, R. (1993). Biophilia, biophobia, and natural landscapes. *Biophilia, Biophobia, and Natural Landscapes*, 73–137.

United Nations. (2019). *World urbanization prospects: The 2018 revision*. Department of Economic and Social Affairs, Population Division.

van den Berg, A. E., Koole, S. L., & van der Wulp, N. Y. (2003). Environment preference and restoration: (How) are they related? *Journal of Environmental Psychology*, *23*(2), 135–146. https://doi.org/10.1016/S0272-4944(02)00111-1 van den Berg, A. E., Maas, J., Verheij, R. A., & Groenewegen, P. P. (2010). Green space as a buffer between stressful life events and health. *Social Science & Medicine (1982)*, *70*(8), 1203–1210. https://doi.org/10.1016/j.socscimed.2010.01.002

Van Eck, N. J., & Waltman, L. (2019, September 16). *VOSviewer Manual*. University of Leiden. https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.13.pdf

van Rijswijk, L., & Haans, A. (2018). Illuminating for Safety: Investigating the Role of Lighting Appraisals on the Perception of Safety in the Urban Environment. *Environment and Behavior*, *50*(8), 889–912. https://doi.org/10.1177/0013916517718888

Vlasiuk, A., & Asari, H. (2021). Feedback from retinal ganglion cells to the inner retina. *PLOS ONE*, *16*(7), e0254611. https://doi.org/10.1371/journal.pone.0254611

Wekerle, G. (2000). From Eyes on the Street to Safe Cities [Speaking of Places]. *Places*, *13*(1). https://escholarship.org/uc/item/8mh913kc

Wertheimer, M., & Riezler, K. (1944). Gestalt Theory. *Social Research*, *11*(1), 78–99.

Westover, T. N. (1985). Perceptions of Crime and Safety in Three Midwestern Parks*. *The Professional Geographer*, *37*(4), 410–420. https://doi.org/10.1111/j.0033-0124.1985.00410.x

White, K. S., & Farrell, A. D. (2006). Anxiety and Psychosocial Stress as Predictors of Headache and Abdominal Pain in Urban Early Adolescents. *Journal of Pediatric Psychology*, *31*(6), 582–596. https://doi.org/10.1093/jpepsy/jsj050

Whittingham, M. J., Stephens, P. A., Bradbury, R. B., & Freckleton, R. P. (2006). Why do we still use stepwise modelling in ecology and behaviour? *Journal of Animal Ecology*, *75*(5), 1182–1189. https://doi.org/10.1111/j.1365-2656.2006.01141.x

Williams, R. J. (2004). *The Anxious City: British Urbanism in the late 20th Century*. Routledge.

Winter, M., & Tyree, K. (2021). Polyvagal Theory. In T. K. Shackelford & V. A. Weekes-Shackelford (Eds.), *Encyclopedia of Evolutionary Psychological Science* (pp. 6062–6066). Springer International Publishing. https://doi.org/10.1007/978-3-319-19650-3_2311

Wolfe, J. M. (2021). Guided Search 6.0: An updated model of visual search. *Psychonomic Bulletin & Review*, *28*(4), 1060–1092. https://doi.org/10.3758/s13423-020-01859-9

Xiao, X., Dong, L., Yan, H., Yang, N., & Xiong, Y. (2018). The Influence of the Spatial Characteristics of Urban Green Space on the Urban Heat Island Effect in Suzhou Industrial Park. *Sustainable Cities and Society*, *40*. https://doi.org/10.1016/j.scs.2018.04.002

Yang, B., Li, S., Elder, B., & Wang, Z. (2013). Community planning approach and residents' perceived safety: A landscape analysis of park design in the Woodlands, Texas. *Journal of Architectural and Planning Research*, *30*, 311–327.

Yang, T., Barnett, R., Fan, Y., & Li, L. (2019). The effect of urban green space on uncertainty stress and life stress: A nationwide study of university students in China. *Health & Place*, *59*, 102199. https://doi.org/10.1016/j.healthplace.2019.102199

Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods*. SAGE Publications.

Yokohari, M., Amemiya, M., & Amati, M. (2006). The history and future directions of greenways in Japanese New Towns. *Landscape and Urban Planning*, *76*(1), 210–222. https://doi.org/10.1016/j.landurbplan.2004.09.033

Zhang, J. W., Howell, R. T., & Iyer, R. (2014). Engagement with natural beauty moderates the positive relation between connectedness with nature and psychological well-being. *Journal of Environmental Psychology*, *38*, 55–63. https://doi.org/10.1016/j.jenvp.2013.12.013

Zhang, Y., Chen, J., & Miller, J. (2005). Determining digital hemispherical photograph exposure for leaf area index estimation. *Agricultural and Forest Meteorology*, *133*, 166–181. https://doi.org/10.1016/j.agrformet.2005.09.009

Zhao, D., Xie, D., Zhou, H., Jiang, H., & An, S. (2012). Estimation of Leaf Area Index and Plant Area Index of a Submerged Macrophyte Canopy Using Digital Photography. *PLOS ONE*, *7*(12), e51034. https://doi.org/10.1371/journal.pone.0051034

Appendix A: Scales used for assessment psychological constructs of safety and comfort

Appendix A.1 – NPSS - Neuroception of Psychological safety scale (Source: Morton et al, 2012)

	NPSS - Neuroception of Psychological safety scale
Social engagement	I felt valued
	I felt comfortable expressing myself
	I felt accepted by others
	I felt understood
	I felt like others got me
	I felt respected
	There was someone who made me feel safe
	There was someone that I could trust
	I felt comforted by others
	I felt heard by others
	I felt like people would try their best to help me
	I felt cared for
	I felt wanted
	I didn't feel judged by others
Compassion	I felt able to empathize with other people
	I felt able to comfort another person if needed
	I felt compassion for others
	I wanted to help others relax
	I felt like I could comfort a loved one
	I felt so connected to others I wanted to help them
	I felt caring
Body sensations	My heart rate felt steady
	Breathing felt effortless
	My voice felt normal
	My body felt relaxed
	My stomach felt settled
	My breathing was steady
	I felt able to stay still
	My face felt relaxed

Appendix A.2: Body perception questionnaire (Source: Chen. 2013)

	BPQ - Body Perception Questionnaire
Awareness	1. Swallowing frequently.
	2. A ringing in my ears.
	3. An urge to cough to clear my throat.
	4. My body swaying when I am standing.
	5. My mouth being dry.
	6. How fast I am breathing.
	7. Watering or tearing of my eyes.
	8. My skin itching.
	9. Noises associated with my digestion.

	10. Eye fatigue or pain.
	11. Muscle tension in my back and neck.
	12. A swelling of my body or parts of my body.
	13. An urge to urinate.
	14. A tremor in my hands.
	15. An urge to defecate.
	16. Muscle tension in my arms and legs.
	17. A bloated feeling because of water retention.
	18. Muscle tension in my face.
	19. Goose bumps.
	20. Facial twitches.
	21. Being exhausted.
	22. Stomach and gut pains.
	23. Rolling or fluttering my eyes.
	24. Stomach distension or bloatedness.
	25. Palms sweating.
	26. Sweat on my forehead.
	27. Clumsiness or bumping into people.
	28. Tremor in my lips.
	29. Sweat in my armpits.
	30. Sensations of prickling, tingling, or numbness in my body.
	31. The temperature of my face (especially my ears).
	32. Grinding my teeth.
	33. General jitteriness.
	34. Muscle pain.
	35. Joint pain.
	36. Fullness of my bladder.
	37. My eye movements.
	38. Back pain.
	39. My nose itching.
	40. The hair on the back of my neck “standing up.”
	41. Needing to rest.
	42. Difficulty in focusing.
	43. An urge to swallow.
	44. How hard my heart is beating.
	45. Feeling constipated
Stress Response	46. Vascular responses such as my face becoming flushed or pallid, or feeling faint.
	47. Body posture shifts such as being hunched over, head down, and knees locked.
	48. Muscle tone or tremor such as arms and legs feeling weak, hands shaking, and lips quivering.
	49. Breathing more rapidly and shallowly and having difficulty in catching my breath.

	50. Digestive responses including gastric distress, gas, cramps, and diarrhoea.
	51. Difficulty in paying attention, with my mind wandering or daydreaming.
	52. Difficulties in sensory abilities such as problems hearing, seeing, smelling, or feeling touch.
	53. Emotional problems such as more frequent feelings of depression, frustration, rage, or anger.
	54. Difficulty organizing my thoughts.
	55. Difficulty speaking clearly and understandably.
Autonomic Nervous System Reactivity	56. I feel nauseous.
	57. I have difficulty coordinating breathing and eating.
	58. My nose is runny, even when I am not sick.
	59. When I am eating, I have difficulty talking.
	60. My heart often beats irregularly.
	61. When I eat, food feels dry and sticks to my mouth and throat.
	62. I have a “sour” stomach.
	63. I feel like vomiting.
	64. I feel short of breath.
	65. I have difficulty coordinating breathing with talking.
	66. When I eat, I have difficulty coordinating swallowing, chewing, and/or sucking with breathing.
	67. I have a persistent cough that interferes with my talking and eating.
	68. I drool, especially when I am excited.
	69. I gag from the saliva in my mouth.
	70. I produce a lot of saliva even when I am not eating.
	71. I have difficulty adjusting my eyes to changes in illumination.
	72. I have chest pains.
	73. I gag when I eat.
	74. When I talk, I often feel I should cough or swallow the saliva in my mouth.
	75. I am constipated.
	76. I have indigestion.
	77. After eating, I have digestive problems.
	78. I have diarrhoea.
	79. When I breathe, I feel as though I cannot get enough oxygen.
	80. I have difficulty controlling my eyes.
	81. I get dizzy when urinating or having a bowel movement.
	82. I have trouble focusing when I go into dimly or brightly illuminated places.
Stress Style 1	83. I approach the problem head-on.
	84. I withdraw.
	85. I know that things will be better later, so I wait until I feel better before acting.

	86. I know that things will go better if I act immediately.
	87. I feel mental tension.
	88. I feel frustrated.
	89. I feel insecure.
	90. I feel aimless
Stress Style 2	91. I feel dizzy.
	92. I have difficulty speaking.
	93. I feel a tingling in my face.
	94. I feel my blood sugar drop

Appendix A.3 – Perceived Restoration scale (Source: Hartig et al, 1997)

	Perceived Restoration Scale (PRS)
Being away	It is an escape experience
	Spending time here gives me a good break from my day-to-day routine
Fascination	The setting has fascinating qualities
	My attention drawn to many interesting things
	I would like to get to know this place better
	I want to explore and discover here
	I would like to spend more time looking at the surroundings
Coherence (extent)	There is too much going on
	It is a confusing place
	There is a great deal of distraction
	It is chaotic here
Compatibility	I can do things I like here
	I have a sense that I belong here
	I have a sense of oneness with this setting
	Being here suits my personality
	I could find ways to enjoy myself in a place like this

Appendix A.4 – Revised Restoration scale (Source: Han, 2003)

	Revised Restoration Scale (Han 2003)
Emotional	I feel elated/ depressed
	I feel confident/ unsure
	I feel good natured/ grouchy
	I feel relaxed/ anxious
	I feel energetic/ fatigued
Physiological	My breathing is becoming faster
	My muscles are becoming tenser
	My hands are sweating
	My heart is beating faster

Cognitive	I am interested in the presented scene
	I feel attentive to the present scene
	My mental fatigue is decreasing
	I feel concentrated in my mind
	I feel reflective of myself
Behavioural	I would like to explore this place further
	I would like to visit here more often
	I would like to stay here longer

Appendix B: Outputs of Principal Component Analysis

Appendix B.1 – Statistical analysis output of Principal Component Analysis

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.792
Bartlett's Test of Sphericity	Approx. Chi-Square	2729.007
	df	561
	Sig.	.000

Communalities

	Initial	Extraction
I feel elated looking at the surrounding (V1)	1.000	.748
I feel relaxed looking at the surrounding (V2)	1.000	.483
I feel concentrated in this space (V3)	1.000	.626
Its calm and quiet (comparatively) here (V4)	1.000	.714
I feel attentive to my surrounding (V5)	1.000	.656
I prefer what I see here (V6)	1.000	.696
I am interested in the scenes from this space (V7)	1.000	.679
I would like to stay here longer (V8)	1.000	.746
I would visit this place again (V9)	1.000	.675
The scenery has fascinating qualities (V10)	1.000	.611
I enjoy being here (V11)	1.000	.675
I feel energetic being in this place (V12)	1.000	.722
I feel pleasant spending time here (V13)	1.000	.768
I feel cheerful looking at the sceneries (V14)	1.000	.725
What I see here is more attractive (V15)	1.000	.567
I feel connected with this space (V16)	1.000	.493
I am satisfied with what I see in this space (V17)	1.000	.495
I can freely enjoy my self here (V18)	1.000	.728
I forgets all the problems when I am here (V19)	1.000	.600
My mental fatigue keeps decreasing when I am here (V20)	1.000	.610
I feel refreshing being here despite the thermal conditions (V21)	1.000	.485
I would love to explore and discover more in this space (V22)	1.000	.635
My eyes are not tired at all (V23)	1.000	.742
My breathing is effortless in this space (V24)	1.000	.825
My heart rate is steady (V25)	1.000	.735
I feel confident to do what I like here (V26)	1.000	.665
I feel comfortable expressing myself in this space (V27)	1.000	.641
I feel like people in this space would try their best to help me (V28)	1.000	.599
I feel accepted by other users (V29)	1.000	.753

I don't feel intimidated by the other users (V30)	1.000	.775
I didn’t feel judged by others (V31)	1.000	.711
My body felt relaxed (V32)	1.000	.723
I feel there are no threats in the surrounding (V33)	1.000	.631
I feel harmless in this space (V34)	1.000	.507

Extraction Method: Principal Component Analysis.

Correlation Matrix[a]

		I feel elated looking at the surrounding (V1)	I feel relaxed looking at the surrounding (V2)	I feel concentrated in this space (V3)	Its calm and quiet (comparatively) here (V4)	I feel attentive to my surrounding (V5)	I prefer what I see here (V6)	I am interested in the scenes from this space (V7)	I would like to stay here longer (V8)	I would visit this place again (V9)	The scenery has fascinating qualities (V10)	I enjoy being here (V11)	I feel energetic being in this place (V12)	I feel pleasant spending time here (V13)	I feel cheerful looking at the sceneries (V14)	What I see here is more attractive (V15)	I feel connected with this space (V16)	I am satisfied with what I see in this space (V17)	I can freely enjoy my self here (V18)	I forgets all the problems when I am here (V19)	My mental fatigue keeps decreasing when I am here (V20)	I feel refreshing being here despite the thermal conditions (V21)	I would love to explore and discover more in this space (V22)	My eyes are not tired at all (V23)	My breathing is effortless in this space (V24)	My heart rate is steady (V25)	I feel confident to do what I like here (V26)	I feel comfortable expressing myself in this space (V27)	I feel like people in this space would try their best to help me (V28)	I feel accepted by other users (V29)	I don't feel intimidated by the other users (V30)	I didn't feel judged by others (V31)	My body felt relaxed (V32)	I feel there are no threats in the surrounding (V33)	I feel harmless in this space (V34)
Correlation	I feel elated looking at the surrounding (V1)	1.000	-.026	.383	-.120	.056	-.060	-.002	.163	.014	-.091	-.128	.023	-.177	-.085	.094	.142	.042	-.239	.158	.210	-.083	.276	.302	.146	.110	.017	-.034	.146	-.021	-.029	.081	.015	.242	.148
	I feel relaxed looking at the surrounding (V2)	-.026	1.000	-.008	.479	.031	.304	.196	.006	.080	.312	.314	.201	.243	.182	.156	-.058	.016	.177	.019	-.134	.013	-.187	.095	-.026	.033	.206	.162	-.143	-.014	.034	.081	.032	-.249	-.083
	I feel concentrated in this space (V3)	.383	-.008	1.000	-.050	.352	-.001	.050	.061	-.009	-.227	-.386	-.212	-.299	-.157	-.060	.074	.063	-.336	-.017	.043	-.308	.475	.050	.147	.101	-.041	-.124	.107	-.009	-.152	-.115	.113	.336	.256
	Its calm and quiet (comparatively) here (V4)	-.120	.479	-.050	1.000	.055	.568	.436	-.148	.010	.470	.296	.287	.253	.307	.254	-.043	.226	.276	-.040	-.174	.099	-.226	.175	-.096	.026	.103	.131	-.297	.027	-.001	-.015	-.016	-.355	-.119
	I feel attentive to my surrounding (V5)	.056	.031	.352	.055	1.000	.287	.218	-.023	.015	-.028	-.171	.056	-.059	.076	.040	.251	.052	-.081	.062	-.022	-.089	.292	-.023	.120	-.034	.088	-.068	.100	.040	-.039	-.026	.074	.159	.136
	I prefer what I see here (V6)	-.060	.304	-.001	.568	.287	1.000	.639	.080	.141	.416	.159	.300	.217	.268	.279	.046	.199	.164	.128	-.021	.044	-.047	.170	.035	-.098	.181	.150	-.131	.059	.051	.077	.051	-.131	-.020

I am interested in the scenes from this space (V7)	-.002	.196	.050	.436	.218	.639	1.000	.151	.189	.417	.164	.348	.183	.273	.221	.150	.277	.242	.118	-.001	.019	.039	.176	.030	-.090	.070	.073	-.267	.009	.041	.128	.090	-.125	.000
I would like to stay here longer (V8)	.163	.006	.061	-.148	-.023	.080	.151	1.000	.434	.055	.035	.123	.108	.001	.140	.125	.078	.037	.097	.135	.118	.049	-.033	.130	-.019	-.072	.036	.152	-.020	.099	.030	-.041	.122	.014
I would visit this place again (V9)	.014	.080	-.009	.010	.015	.141	.189	.434	1.000	.071	.113	.234	.146	.074	.106	.109	.170	.145	.135	.146	.042	.108	-.050	.074	.042	.069	.077	.071	.122	.182	.164	.072	.129	.102
The scenery has fascinating qualities (V10)	-.091	.312	-.227	.470	-.028	.416	.417	.055	.071	1.000	.315	.420	.325	.402	.354	.030	.225	.294	.129	-.030	.088	-.148	.132	-.080	-.102	.147	.234	-.097	.007	.081	.149	.211	-.245	-.092
I enjoy being here (V11)	-.128	.314	-.386	.296	-.171	.159	.164	.035	.113	.315	1.00	.623	.594	.420	.317	-.009	.098	.379	.152	.060	.362	-.351	-.096	.027	.100	.371	.395	-.104	.160	.343	.272	.111	-.257	-.024
I feel energetic being in this place (V12)	.023	.201	-.212	.287	.056	.300	.348	.123	.234	.420	.623	1.000	.643	.598	.445	.146	.304	.274	.183	.159	.252	-.063	.087	.078	.045	.372	.388	-.025	.155	.273	.258	.104	-.143	.085
I feel pleasant spending time here (V13)	-.177	.243	-.299	.253	-.059	.217	.183	.108	.146	.325	.594	.643	1.000	.642	.465	-.002	.175	.421	.184	.118	.397	-.307	-.057	.159	.192	.390	.493	.085	.263	.467	.421	.020	-.137	.071
I feel cheerful looking at the sceneries (V14)	-.085	.182	-.157	.307	.076	.268	.273	.001	.074	.402	.420	.598	.642	1.000	.588	.144	.351	.406	.310	.202	.338	-.092	.180	.157	.159	.438	.503	.021	.242	.315	.248	.052	-.053	.089
What I see here is more attractive (V15)	.094	.156	-.060	.254	.040	.279	.221	.140	.106	.354	.317	.445	.465	.588	1.000	.199	.339	.243	.277	.248	.214	.033	.192	.150	.132	.354	.307	-.029	.145	.325	.215	.148	.003	.068
I feel connected with this space (V16)	.142	-.058	.074	-.043	.251	.046	.150	.125	.109	.030	-.009	.146	-.002	.144	.199	1.000	.227	.073	.237	.228	-.035	.224	.198	.142	.094	-.003	-.030	.075	.029	.032	.024	.011	.199	.185
I am satisfied with what I see in this space (V17)	.042	.016	.063	.226	.052	.199	.277	.078	.170	.225	.098	.304	.175	.351	.339	.227	1.000	.378	.321	.272	.117	.097	.245	.188	.151	.188	.208	-.039	.225	.155	.145	.104	.047	.104
I can freely enjoy my self here (V18)	-.239	.177	-.336	.276	-.081	.164	.242	.037	.145	.294	.379	.274	.421	.406	.243	.073	.378	1.000	.493	.227	.370	-.236	.065	.188	.224	.295	.375	-.003	.240	.393	.340	.078	-.159	.018
I forgets all the problems when I am here (V19)	.158	.019	-.017	-.040	.062	.128	.118	.097	.135	.129	.152	.183	.184	.310	.277	.237	.321	.493	1.000	.470	.248	.132	.234	.250	.255	.305	.389	.280	.214	.245	.271	.144	.160	.225
My mental fatigue keeps decreasing when I am here (V20)	.210	-.134	.043	-.174	-.022	-.021	-.001	.135	.146	-.030	.060	.159	.118	.202	.248	.228	.272	.227	.470	1.000	.288	.197	.164	.197	.198	.216	.258	.365	.265	.279	.239	.116	.266	.262

I feel refreshing being here despite thermal conditions (V21)	-.083	.013	-.308	.099	-.089	.044	.019	.118	.042	.088	.362	.252	.397	.338	.214	-.035	.117	.370	.248	.288	1.000	-.203	.146	.250	.234	.262	.373	.174	.352	.303	.289	-.033	-.033	.010
I would love to explore and discover more in this space (V22)	.276	-.187	.475	-.226	.292	-.047	.039	.049	.108	-.148	-.351	-.063	-.307	-.092	.033	.224	.097	-.236	.132	.197	-.203	1.000	.146	.255	.091	.015	-.120	.257	.102	-.036	-.015	.192	.540	.333
My eyes are not tired at all (V23)	.302	.095	.050	.175	-.023	.170	.176	-.033	-.050	.132	-.096	.087	-.057	.180	.192	.198	.245	.065	.234	.164	.146	.146	1.00	.475	.353	.160	.120	.051	.108	-.050	.069	.045	.065	-.047
My breathing is effortless in this space (V24)	.146	-.026	.147	-.096	.120	.035	.030	.130	.074	-.080	.027	.078	.159	.157	.150	.142	.188	.188	.250	.197	.250	.255	.475	1.000	.664	.359	.304	.289	.300	.314	.338	.194	.268	.083
My heart rate is steady (V25)	.110	.033	.101	.026	-.034	-.098	-.090	-.019	.042	-.102	.100	.045	.192	.159	.132	.094	.151	.224	.255	.198	.234	.091	.353	.664	1.000	.361	.384	.272	.350	.344	.327	.063	.152	.191
I feel confident to do what I like here (V26)	.017	.206	-.041	.103	.088	.181	.070	-.072	.069	.147	.371	.372	.390	.438	.354	-.003	.188	.295	.305	.216	.262	.015	.160	.359	.361	1.000	.677	.132	.360	.400	.377	.255	.065	.220
I feel comfortable expressing myself in this space (V27)	-.034	.162	-.124	.131	-.068	.150	.073	.036	.077	.234	.395	.388	.493	.503	.307	-.030	.208	.375	.389	.258	.373	-.120	.120	.304	.384	.677	1.000	.297	.446	.456	.435	.157	.011	.238
I feel like people in this space would try their best to help me (V28)	.146	-.143	.107	-.297	.100	-.131	-.267	.152	.071	-.097	-.104	-.025	.085	.021	-.029	.075	-.039	-.003	.280	.365	.174	.257	.051	.289	.272	.132	.297	1.000	.473	.399	.370	.121	.450	.288
I feel accepted by other users (V29)	-.021	-.014	-.009	.027	.040	.059	.009	-.020	.122	.007	.160	.155	.263	.242	.145	.029	.225	.240	.214	.265	.352	.102	.108	.300	.350	.360	.446	.473	1.000	.693	.625	.086	.254	.253
I don't feel intimidated by the other users (V30)	-.029	.034	-.152	-.001	-.039	.051	.041	.099	.182	.081	.343	.273	.467	.315	.325	.032	.155	.393	.245	.279	.303	-.036	-.050	.314	.344	.400	.456	.399	.693	1.000	.758	.099	.184	.245
I didn’t feel judged by others (V31)	.081	.081	-.115	-.015	-.026	.077	.128	.030	.164	.149	.272	.258	.421	.248	.215	.024	.145	.340	.271	.239	.289	-.015	.069	.338	.327	.377	.435	.370	.625	.758	1.000	.167	.161	.220
My body felt relaxed (V32)	.015	.032	.113	-.016	.074	.051	.090	-.041	.072	.211	.111	.104	.020	.052	.148	.011	.104	.078	.144	.116	-.033	.192	.045	.194	.063	.255	.157	.121	.086	.099	.167	1.000	.207	.176
I feel there are no threats in the surrounding (V33)	.242	-.249	.336	-.355	.159	-.131	-.125	.122	.129	-.245	-.257	-.143	-.137	-.053	.003	.199	.047	-.159	.160	.266	-.033	.540	.065	.268	.152	.065	.011	.450	.254	.184	.161	.207	1.000	.481

	I feel harmless in this space (V34)	.148	-.083	.256	-.119	.136	-.020	.000	.014	.102	-.092	-.024	.085	.071	.089	.068	.185	.104	.018	.225	.262	.010	.333	-.047	.083	.191	.220	.238	.288	.253	.245	.220	.176	.481	1.000

a. Determinant = 4.27E-008

Appendix C: Interpretation of the 6 Principal Components

PRINCIPAL COMPONENTS – SENSE OF COMFORT

Principal Component 1 – Positive Emotional Experience.

All the variables under this principal component revolve around feelings of positivity, enjoyment, and energy associated with a particular place. The factor with positive loadings for these variables could be interpreted as the "Positive Emotional Experience" factor.

- "I feel pleasant spending time here": This variable suggests that individuals feel comfortable and at ease when they are in the given place. The positive loading on the factor indicates that this feeling of pleasantness contributes to the overall positive environment experience.
- "I feel energetic being in this place": The positive loading on this variable implies that being in this place brings about feelings of energy and vitality in individuals. This feeling of increased energy adds to the positive ambiance of the place.
- "I enjoy being here": The positive loading here suggests that people find the place enjoyable, implying a sense of satisfaction and contentment when spending time there. This feeling of enjoyment contributes to the positive factor.
- "I feel cheerful looking at the sceneries": This variable indicates that the visual aspects of the place, likely referring to its landscapes or views, elicit feelings of cheerfulness. The positive loading indicates that these cheerful feelings align with the positive factor being identified.
- "What I see here is more attractive": This variable implies that the visual aesthetics of the place are appealing and attractive to individuals. The positive loading indicates that this sense of visual attractiveness is a contributing factor to the overall positive experience in the environment.

Taken together, the positive loadings on these variables suggest that there is an underlying factor related to the positive emotional and experiential aspects of the environment. This factor encompasses feelings of pleasantness, energy, enjoyment, cheerfulness from the sceneries, and attractiveness of the surroundings. It's important to note that factor interpretations should be context-specific and can be influenced by the particular domain or scenario being studied.

Principal Component 3 – Visual Engagement and Positive Perception

When all the factor loadings for the variables are positive, it suggests an underlying factor that is directly related to the variables. In this case, the factor with positive loadings for these variables could be interpreted as the "Visual Engagement and Positive Perception" factor, indicating that the environment is associated with feelings of preference, interest, and attentiveness.

- "I prefer what I see here": The positive loading on this variable implies that individuals find the visual aspects of the environment appealing and in line with their preferences. This suggests a positive perception and a sense of liking for what is being observed.

- "I am interested in the scenes from this space": The positive loading here suggests that individuals are interested and engaged with the scenes or surroundings from this space. This interest indicates a positive connection and engagement with the environment.
- "I feel attentive to my surrounding": The positive loading on this variable indicates that individuals feel attentive and focused on their surroundings when in this environment. This attentiveness points to a heightened sense of awareness and engagement with the environment.

Taken together, the positive loadings on these variables suggest that there is an underlying factor related to positive engagement, preference, and attentiveness to the environment. This factor encompasses feelings of preferring the visual aspects, being interested in the scenes, and feeling attentive to the surroundings. Individuals experience a positive connection and engagement with the environment, resulting in a heightened sense of perception and interest. As always, when interpreting factor analyses, it's important to consider the specific context and domain of the study. The positive loadings indicate a direct relationship between the identified factor and the mentioned variables, highlighting the role of the environment in generating positive engagement and perceptions.

Principal Component 4 – Positive Experiential Intent

The factor with positive loadings for these variables could be interpreted as the "Positive Experiential Intent" factor. This factor reflects the positive impressions and experiences individuals have in the environment, leading to a desire to prolong their stay and return for future visits.

- "I would like to stay here longer": The positive loading on this variable implies that individuals wish to extend their stay in the environment. This suggests that they are having a positive experience and would like to continue enjoying the atmosphere, activities, or surroundings.
- "I would visit this place again": The positive loading here indicates that individuals express a desire to revisit the same place in the future. This implies that they are having a positive experience and would like to recreate the enjoyable experience they had during their initial visit.

Taken together, the positive loadings on these variables suggest that there is an underlying factor related to positive experiences and intentions in the environment. This factor encompasses feelings of wanting to stay longer and a strong intention to visit the place again due to the positive experiences they associate with it. The positive loadings indicate a direct relationship between the identified factor and the mentioned variables, highlighting the role of positive experiences in fostering the desire to stay longer and return for future visits.

Principal Component 5 – Positive Social Interaction

The factor with positive loadings for these variables could be interpreted as the "Positive Social Interaction" factor. This factor reflects the positive social dynamics within the environment, where individuals feel comfortable, accepted, and not judged by others.

- "I don't feel intimidated by the other users": The positive loading on this variable implies that individuals experience a lack of intimidation when interacting with or being around other users. This suggests a positive and non-threatening social atmosphere.
- "I feel accepted by other users": The positive loading here indicates that individuals perceive themselves as being accepted and welcomed by other users. This implies a positive social environment that promotes a sense of belonging and inclusiveness.
- "I didn’t feel judged by others": The positive loading on this variable suggests that individuals do not feel negatively evaluated or judged by others in the environment. This indicates a lack of social pressure and supports a positive and non-critical atmosphere.

Taken together, the positive loadings on these variables suggest that there is an underlying factor related to positive social interactions and acceptance in the environment. This factor encompasses feelings of not being intimidated, being accepted, and not feeling judged by other users. Individuals experience a supportive and positive social environment that promotes their well-being and comfort. The positive loadings indicate a direct relationship between the identified factor and the mentioned variables, highlighting the role of positive social dynamics in fostering feelings of comfort, acceptance, and lack of judgment among users.

PRINCIPAL COMPONENTS – SENSE OF SAFETY

Principal Component 2 – Relaxation and Physiological Well-being

When all the factor loadings for the variables are negative, it indicates that these variables are inversely related to the underlying factor that is being identified through a statistical technique like factor analysis. In this case, the factor with negative loadings for these variables could be interpreted as the "Relaxation and Physiological Well-being" factor.

- "My breathing is effortless in this space": The negative loading on this variable suggests that being in this space contributes to a sense of relaxed and effortless breathing. In other words, individuals find it easier to breathe comfortably, indicating a calming and stress-reducing environment.
- "My eyes are not tired at all": The negative loading on this variable indicates that being in this space alleviates eye strain and fatigue. This implies that the environment supports visual comfort and relaxation, possibly due to factors such as adequate lighting and soothing visual elements.
- "My heart rate is steady": The negative loading here suggests that being in this space promotes a stable and calm heart rate. This could reflect a calming and stress-reducing effect on the individual's physiological state.

Taken together, the negative loadings on these variables suggest that there is an underlying factor related to relaxation, comfort, and physiological well-being in the environment. This factor encompasses feelings of effortless breathing, reduced eye strain, and a steady heart rate. Individuals experience a sense of calm and ease when they are in this environment, which contributes to their overall relaxation and comfort. As with any factor analysis interpretation, it's important to consider the specific context and domain of the study. The negative loadings indicate an inverse relationship between the identified factor and the mentioned variables, highlighting the role of the environment in promoting relaxation and comfort.

Principal Component 6 – Stress Relief and Mental Revitalization

The factor with positive loadings for these variables could be interpreted as the "Stress Relief and Mental Revitalization" factor. This factor captures the environment's influence on reducing mental fatigue and providing a respite from everyday problems.

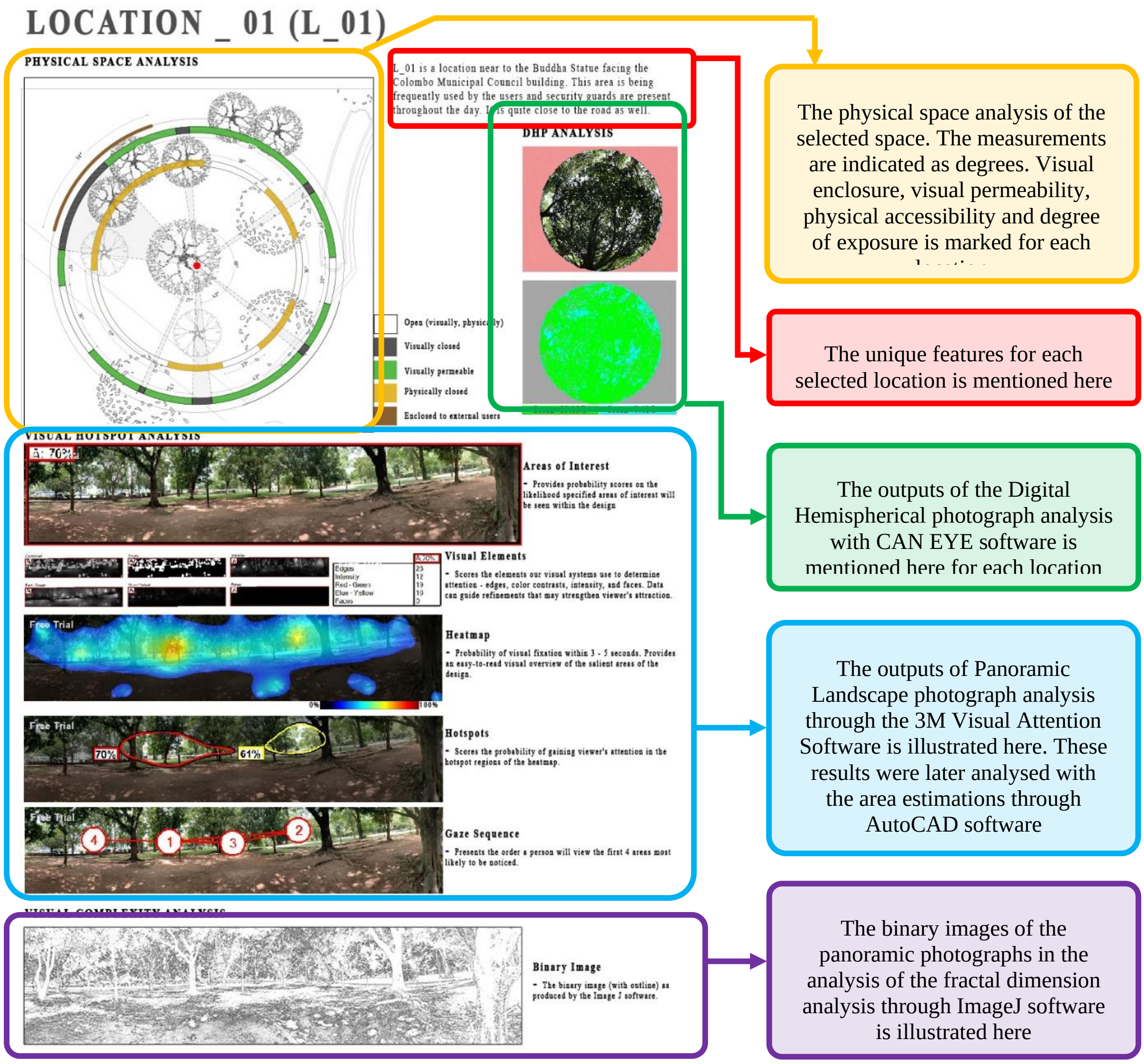
- "My mental fatigue keeps decreasing when I am here": The positive loading on this variable suggests that individuals experience a reduction in mental fatigue and exhaustion when they are in this environment. This indicates that the environment has a positive impact on their mental well-being, helping them feel more refreshed and energized.
- "I forget all the problems when I am here": The positive loading here indicates that individuals experience a sense of escapism from their problems and worries when they are in this environment. This suggests that the environment provides a mental break and allows them to focus on positive experiences, rather than dwelling on stressors.

Taken together, the positive loadings on these variables suggest that there is an underlying factor related to stress relief and mental refreshment in the environment. This factor encompasses feelings of reduced mental fatigue and an escape from everyday problems. Individuals experience a positive mental shift when they are in this environment, contributing to their overall sense of well-being and relaxation. The positive loadings indicate a direct relationship between the identified factor and the mentioned variables, highlighting the role of the environment in promoting stress relief and mental revitalization.

Appendix D: Vegetation configuration Qualities

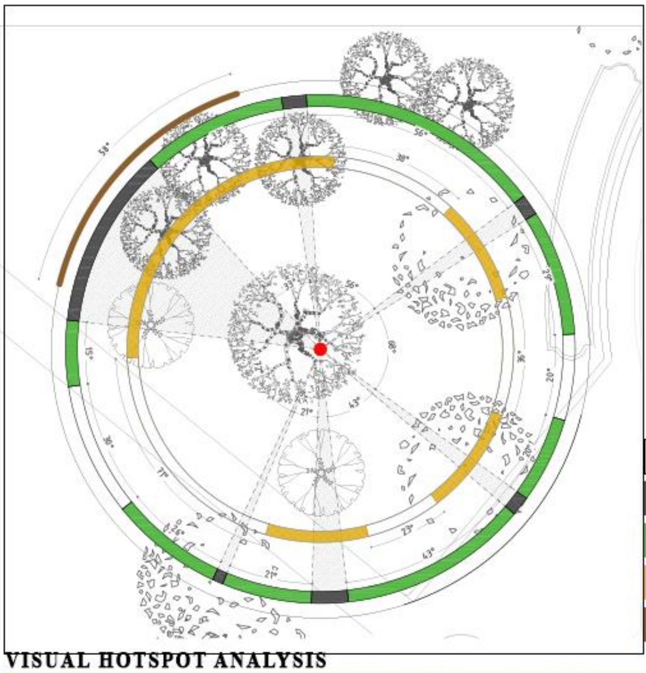
Appendix D.1 – Analysis of Vegetation Configuration Qualities of the 25 Locations.

Here all the selected spaces in the Vihara Maha Devi park are analysed with the (1) physical analysis with measurements of the onsite locations, (2) the Panoramic landscape photographs with 3M Visual Attention software for hotspots and Image J software for fractal diversity and (3) Digital Hemispherical Photograph analysis with Can EYE software.



LOCATION _ 01 (L_01)

PHYSICAL SPACE ANALYSIS



Open (visually, physically)

Visually closed

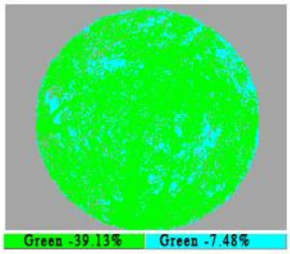
Visually permeable

Physically closed

Enclosed to external users

L_01 is a location near to the Buddha Statue facing the Colombo Municipal Council building. This area is being frequently used by the users and security guards are present throughout the day. It is quite close to the road as well.

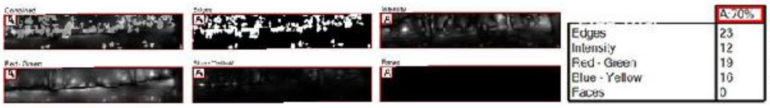
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

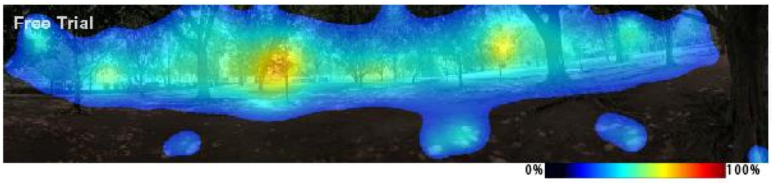
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design



Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

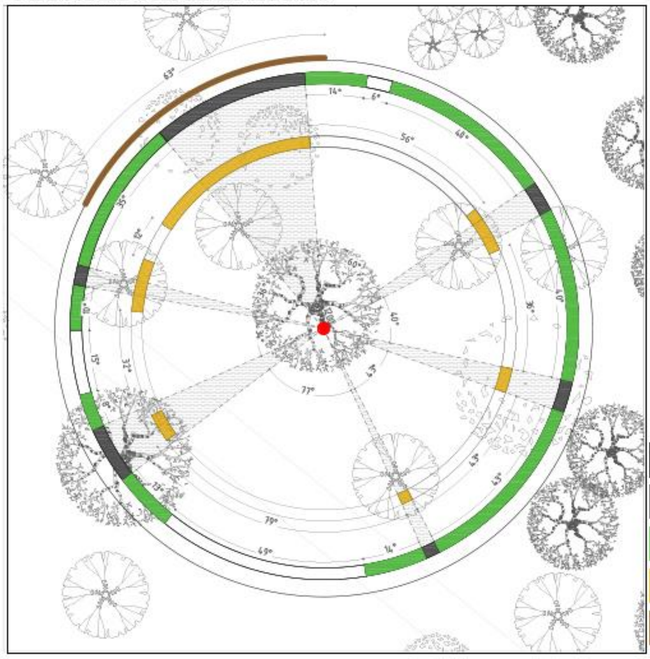
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 02 (L_02)

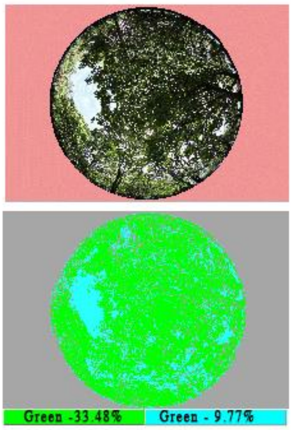
PHYSICAL SPACE ANALYSIS



L_02 is also a location near to the Buddha Statue facing the Colombo Municipal Council building. This area is being frequently used by the users and security guards are present throughout the day.

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

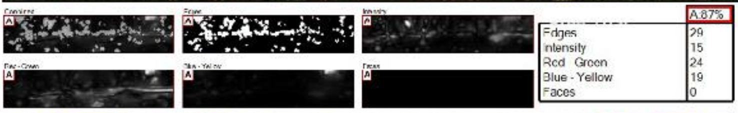
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

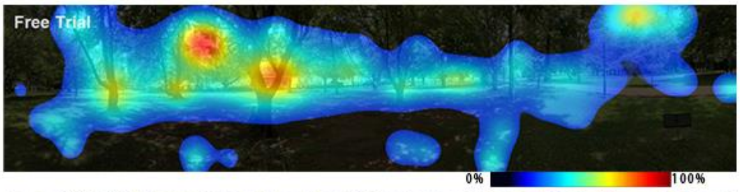
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design



Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.

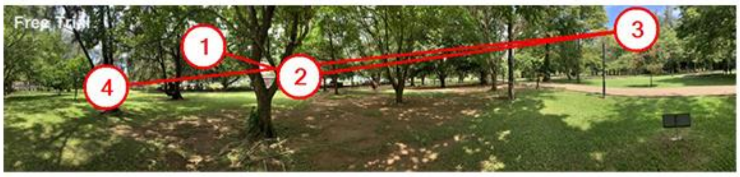


Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.



Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

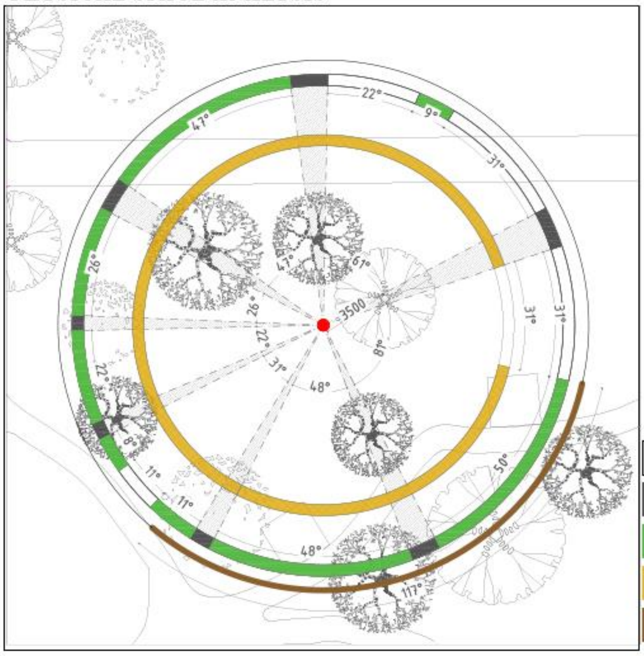
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 03 (L_03)

PHYSICAL SPACE ANALYSIS



L_03 is located in the Picnic area in between small picnic huts. This area is being frequently used by the users as there are designated spaces for waiting and gathering in this area. This space is also facing a pathway which is frequently used by the users.

Open (visually, physically)

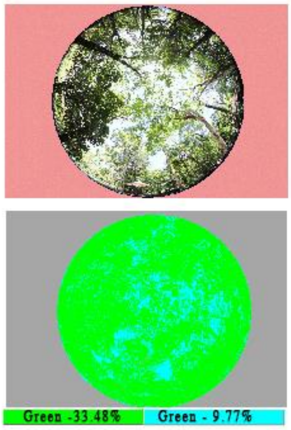
Visually closed

Visually permeable

Physically closed

Enclosed to external users

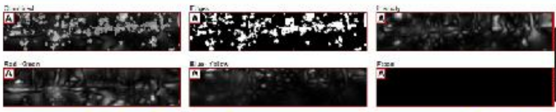
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

Areas of Interest

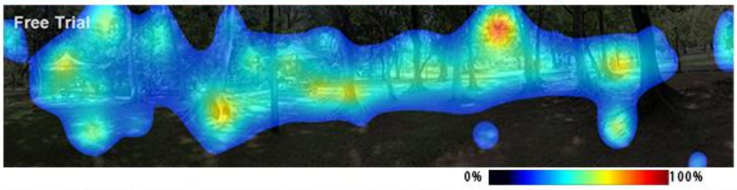
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A:81%
Edges	26
Intensity	14
Red - Green	23
Blue - Yellow	18
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

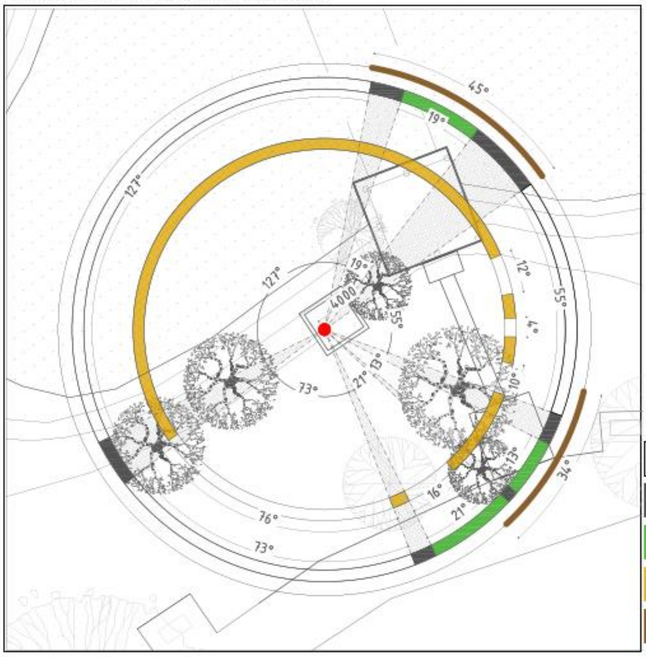
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 04 (L_04)

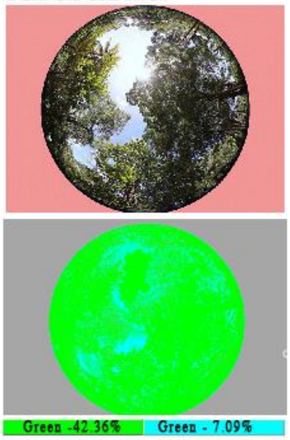
PHYSICAL SPACE ANALYSIS



Open (visually, physically)
Visually closed
Visually permeable
Physically closed
Enclosed to external users

L_04 is a designated seating located near the lake at the Viharamahadevi Park. It is adjacent to the foot of the bridge and near to the playground as well. Both the playground and the lake area is highly functional in the park.

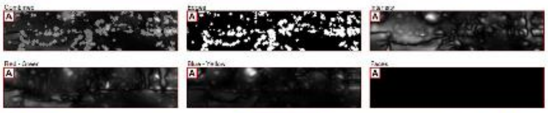
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

Areas of Interest

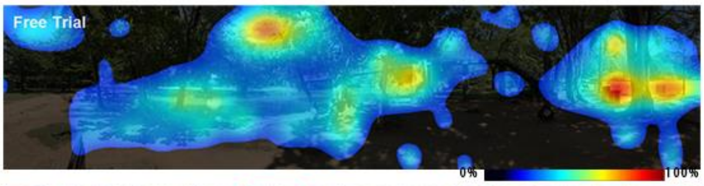
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A: 87%
Edges	29
Intensity	15
Red - Green	24
Blue - Yellow	19
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.

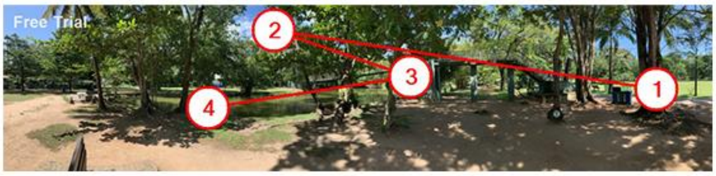


Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.



Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

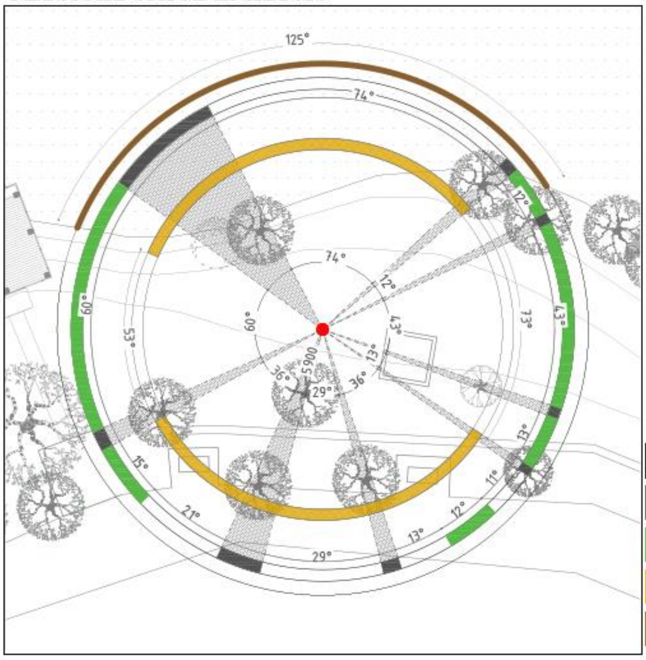
VISUAL COMPLEXITY ANALYSIS

Binary Image

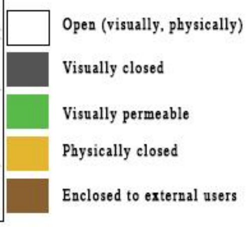
- The binary image (with outline) as produced by the Image J software.

LOCATION _ 05 (L_05)

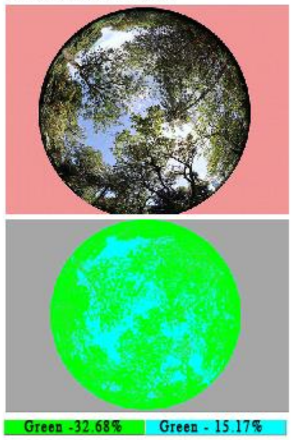
PHYSICAL SPACE ANALYSIS



L_05 is also a designated searing located inbetween the lake and the playground at Viharamahadevi Park. This space is near to the boat service area, a major pathway and the bridge making the space more open to the other users in the park.



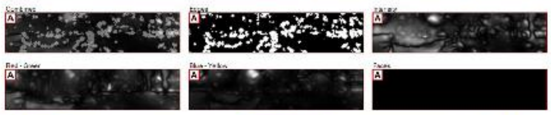
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

Areas of Interest

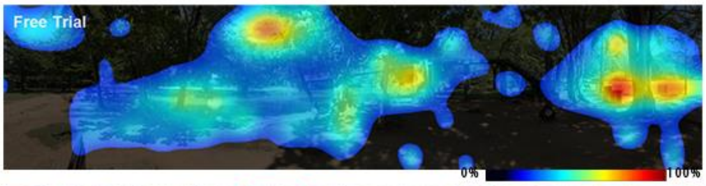
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A:87%
Edges	29
Intensity	15
Red - Green	24
Blue - Yellow	19
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.

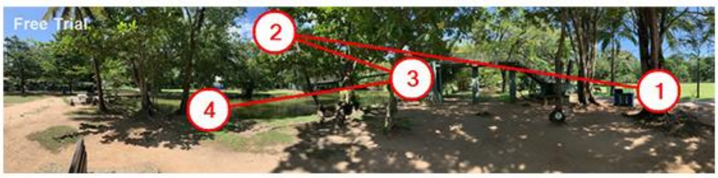


Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.



Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

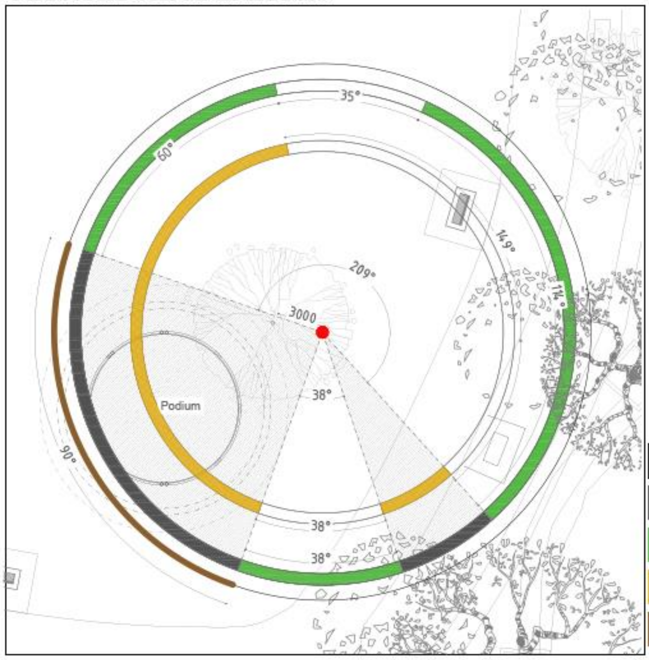
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 06 (L_06)

PHYSICAL SPACE ANALYSIS



L_06 is a located adjacent to the viewing podium at the playground of the park. There is a massive tree which provides a ideal relaxing area underneath. Adjacent to this location is a main pathway of the park which increases the eyes on this place.

Open (visually, physically)

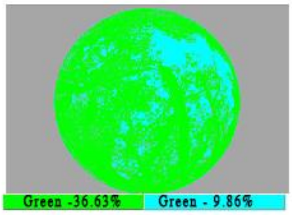
Visually closed

Visually permeable

Physically closed

Enclosed to external users

DHP ANALYSIS

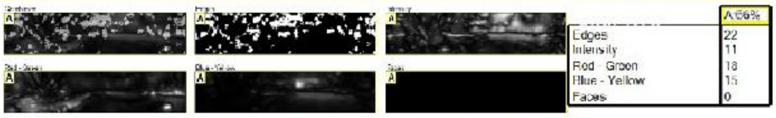


Green -36.63% Green - 9.86%

VISUAL HOTSPOT ANALYSIS

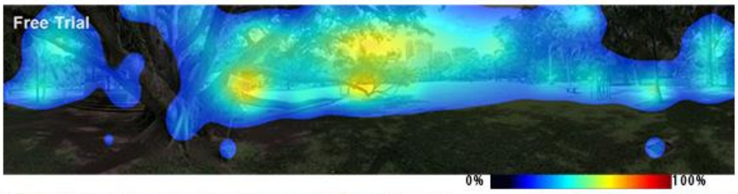
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design



Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

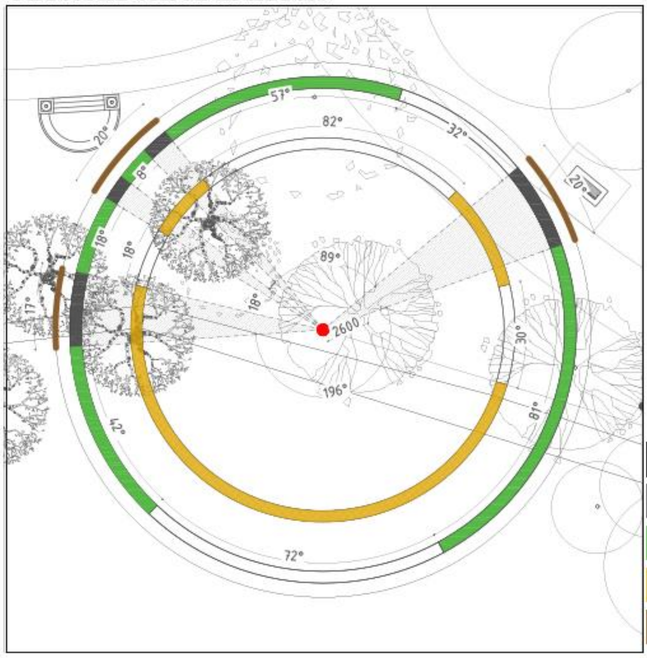
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 07 (L_07)

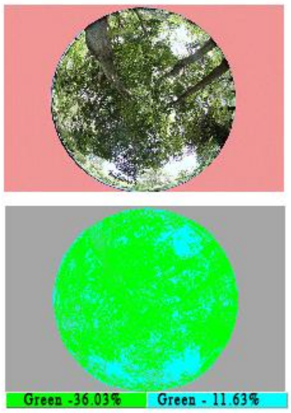
PHYSICAL SPACE ANALYSIS



L_07 is located near to the playground area but a bit secluded from the highly used context. As a result the space is a bit calm and tranquile. A major drain in located near to the space limiting movements to one side. As there are designated seatings in the nearby area, the space is opened to the other users visually

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

DHP ANALYSIS



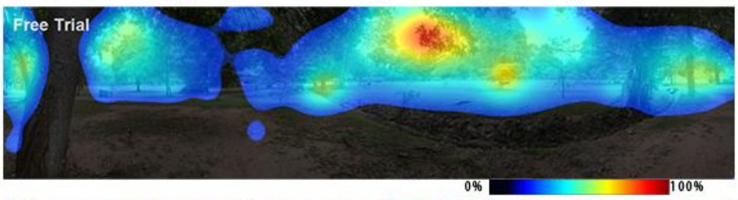
VISUAL HOTSPOT ANALYSIS

Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

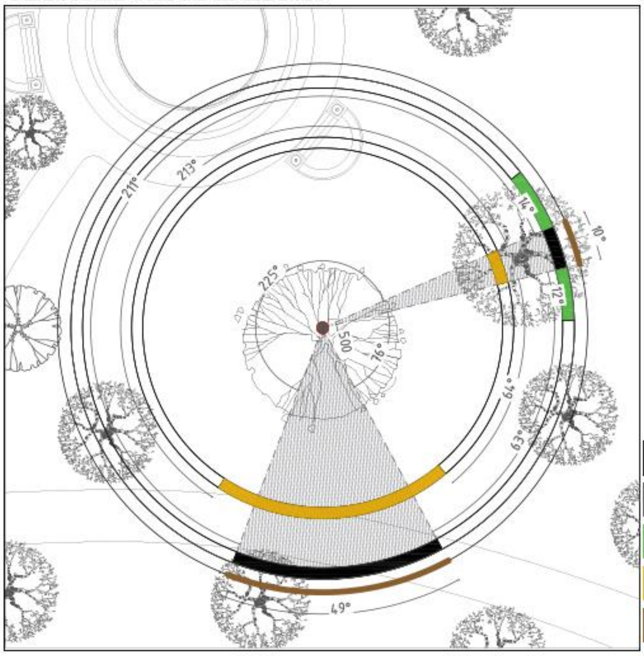
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 08 (L_08)

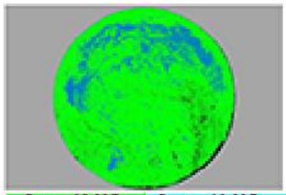
PHYSICAL SPACE ANALYSIS



L_08 is located in the leisure zone away from the playground area. Here mostly users are gathering and relaxing in the turf area as there are less number of designated spaces. The turf is well maintained for the intended uses.

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

DHP ANALYSIS

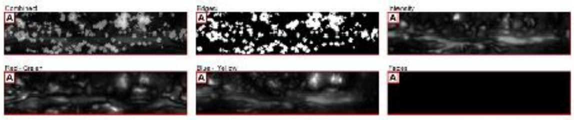


Green -35.20% Green - 13.39%

VISUAL HOTSPOT ANALYSIS

Areas of Interest

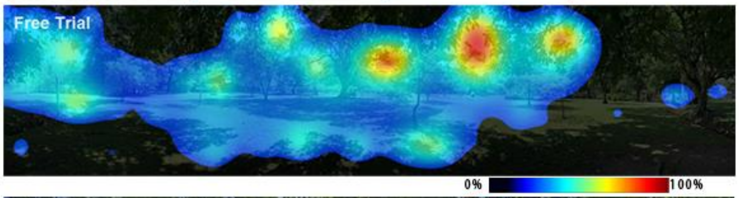
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A:85%
Edges	28
Intensity	14
Red - Green	24
Blue - Yellow	19
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.

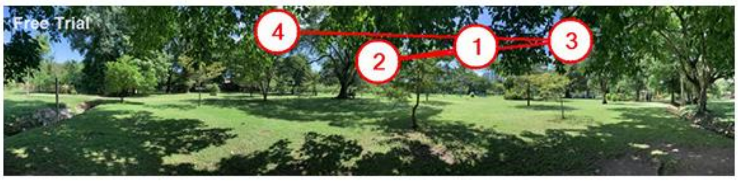


Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

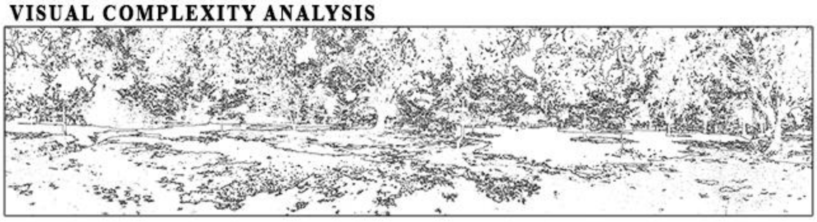
- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.



Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

VISUAL COMPLEXITY ANALYSIS

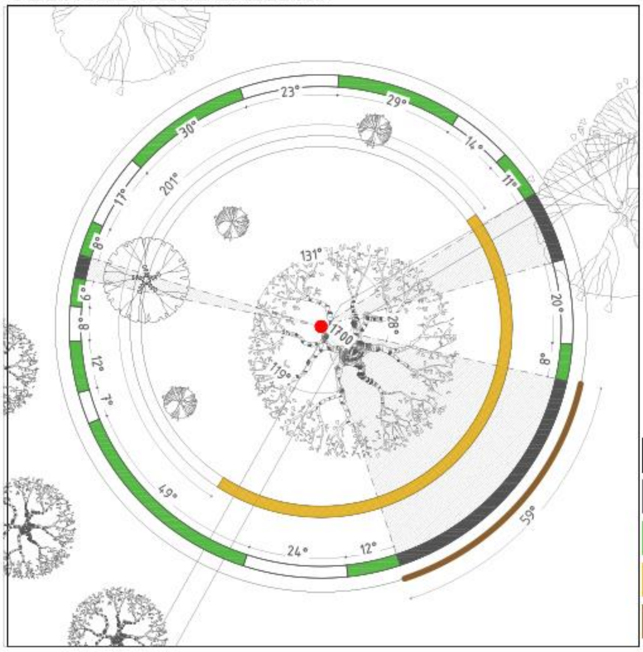


Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 09 (L_09)

PHYSICAL SPACE ANALYSIS



L_09 is also located in the leisure zone away from the playground area. Here mostly users are gathering and relaxing in the turf area as there are less number of designated spaces. The turf is well maintained for the intended uses.

Open (visually, physically)

Visually closed

Visually permeable

Physically closed

Enclosed to external users

DHP ANALYSIS

VISUAL HOTSPOT ANALYSIS

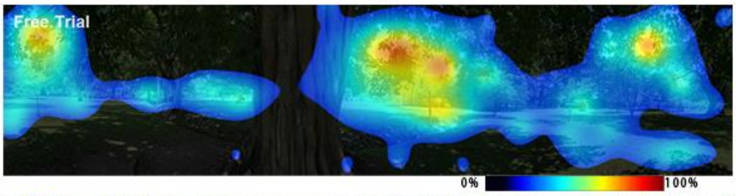
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design

	A 77%
Edges	26
Intensity	13
Red - Green	21
Blue - Yellow	17
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

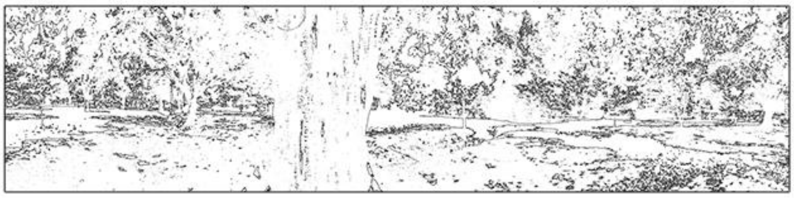
Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

VISUAL COMPLEXITY ANALYSIS

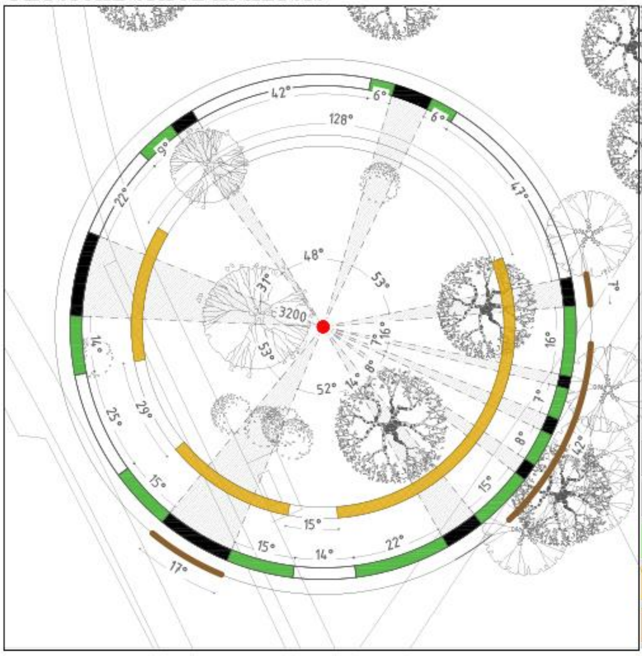


Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 10 (L_10)

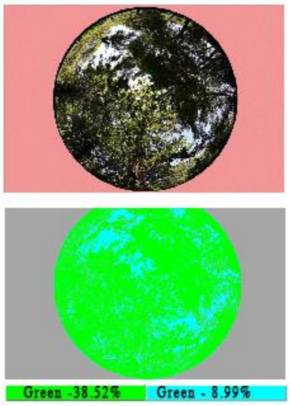
PHYSICAL SPACE ANALYSIS



L_10 is also located in the leisure zone near to the boundary of the park premises. As a result a security hut is located near to this location providing eyes on the space although these areas are not much frequently used by the users.

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

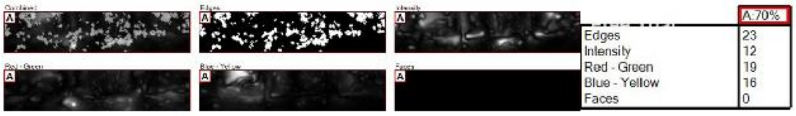
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

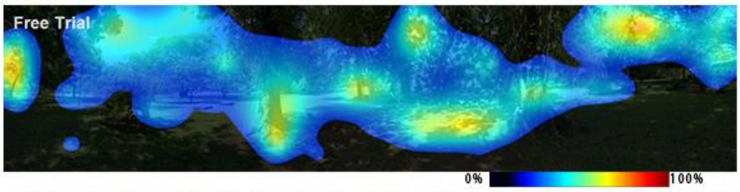
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design



Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

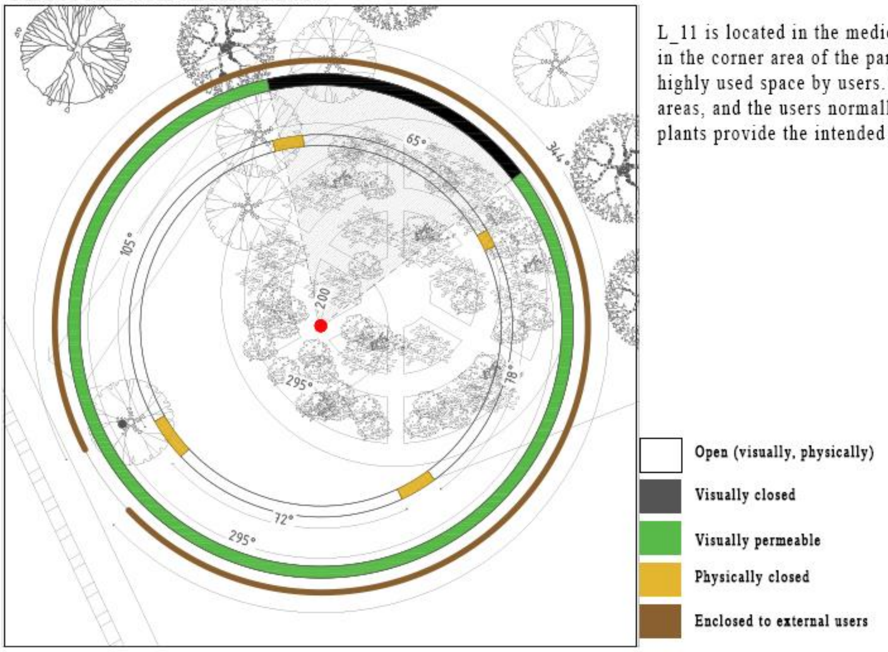
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

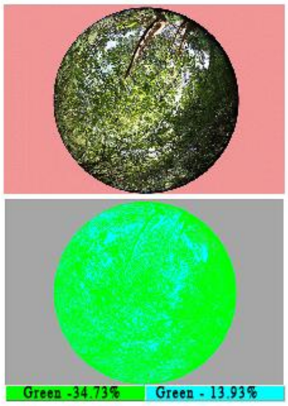
LOCATION _ 11 (L_11)

PHYSICAL SPACE ANALYSIS



L_11 is located in the medicinal herb garden which is designed in the corner area of the park. This space is quite hideous yet a highly used space by users. There are no designated waiting areas, and the users normally stay standing as the low level plants provide the intended comfort for the stay

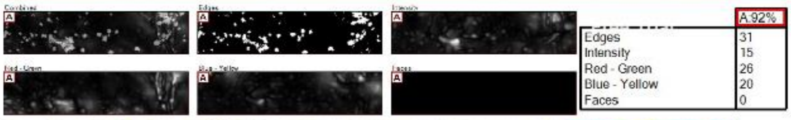
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

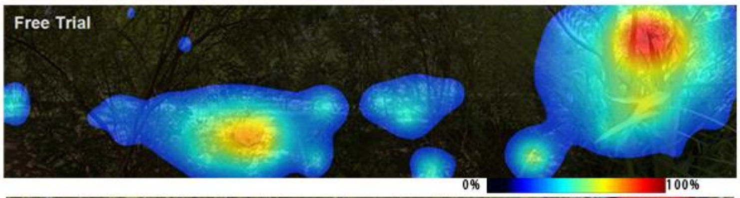
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design



Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

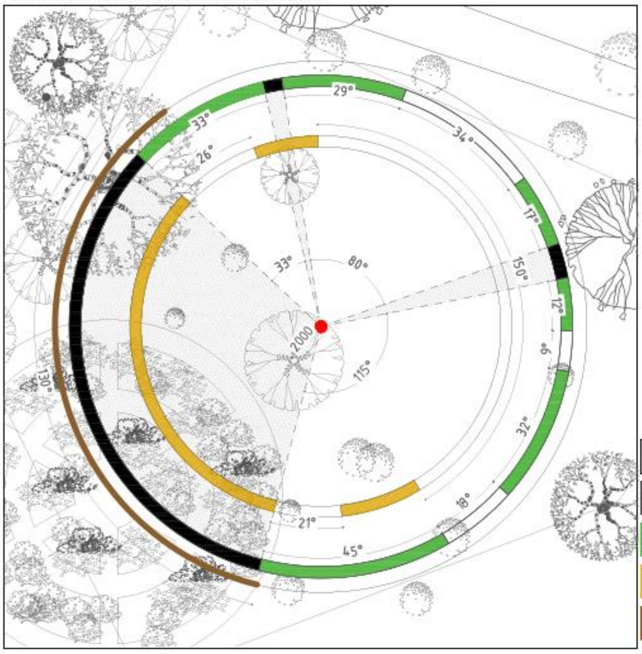
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 12 (L_12)

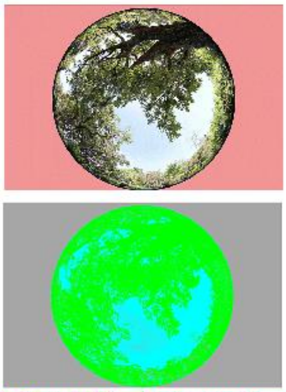
PHYSICAL SPACE ANALYSIS



- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

L_12 is located adjacent to the medicinal herb garden premises in an area named as elephant bath area. This space overlooks into an open land which is frequently used by small children.

DHP ANALYSIS

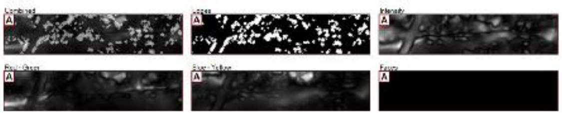


Green -34.01% | Green - 14.66%

VISUAL HOTSPOT ANALYSIS

Areas of Interest

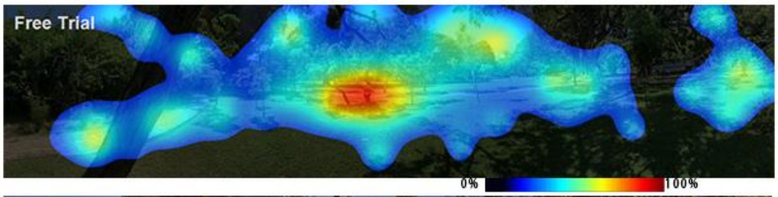
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A:87%
Edges	29
Intensity	15
Red - Green	24
Blue - Yellow	19
Faces	0

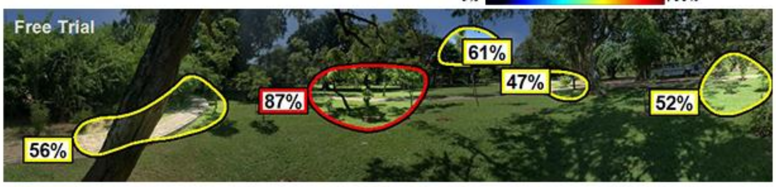
Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



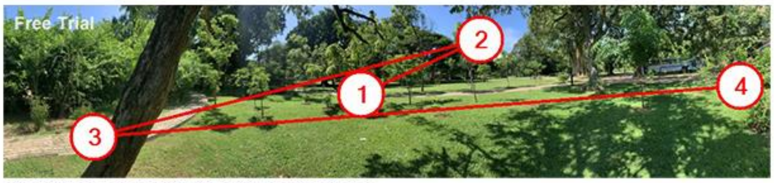
Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.



Hotspots

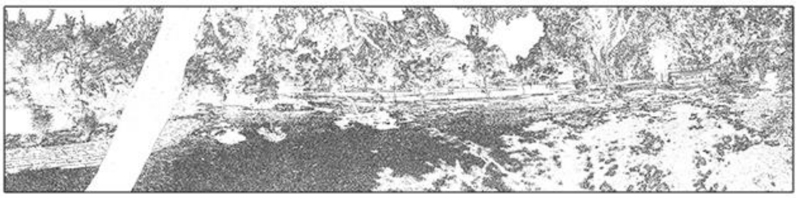
- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.



Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

VISUAL COMPLEXITY ANALYSIS

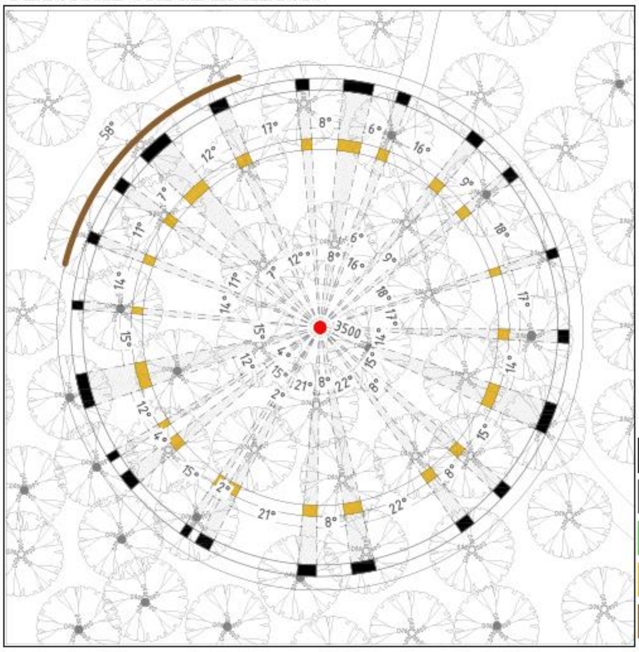


Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 13 (L_13)

PHYSICAL SPACE ANALYSIS



L_13 is located in an adjacent area to the medicinal plantation area. The space is designed with properly alligned pihimbiya trees. This space is aesthetically appealing as a result of the spatial characteristics. This unique space is frequently used by the users due to its aesthetical properties.

Open (visually, physically)

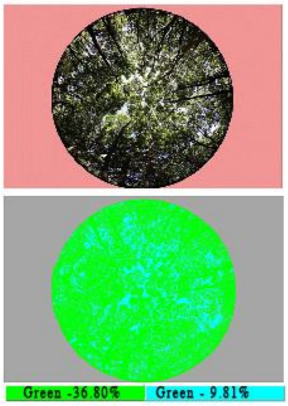
Visually closed

Visually permeable

Physically closed

Enclosed to external users

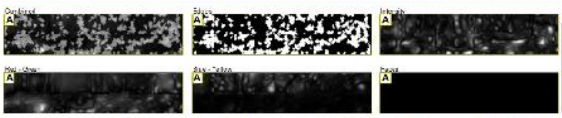
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

Areas of Interest

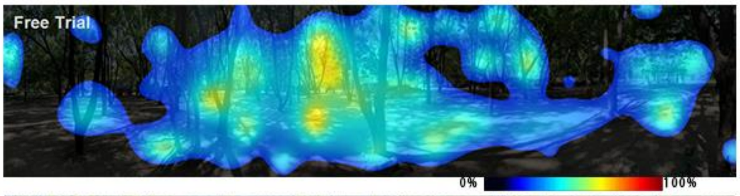
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A:66%
Edges	22
Intensity	11
Red - Green	18
Blue - Yellow	15
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

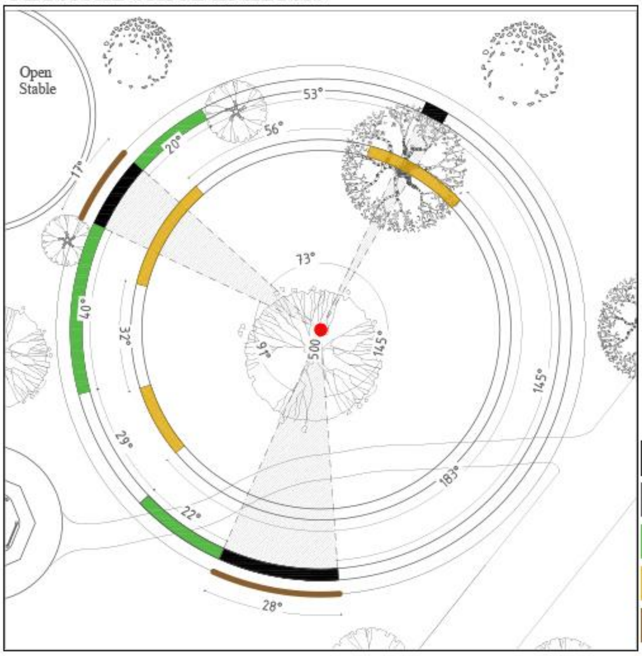
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 14 (L_14)

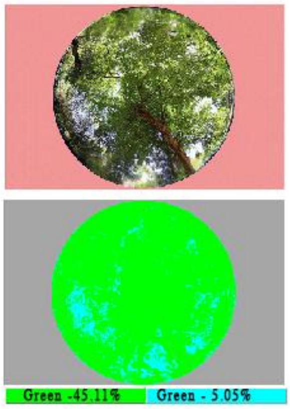
PHYSICAL SPACE ANALYSIS



L_14 is located in an adjacent to an open stable and a waiting hut. As a result people are frequently seen in this area. The space is also near to the boundary of the park which has been cleared for visual access. The space is highly exposed to the eyes of other users.

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

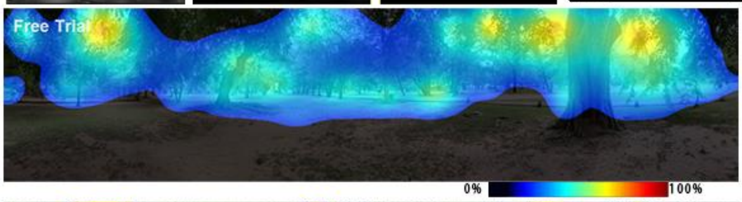
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design

	A:67%
Edges	23
Intensity	11
Red - Green	18
Blue - Yellow	15
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

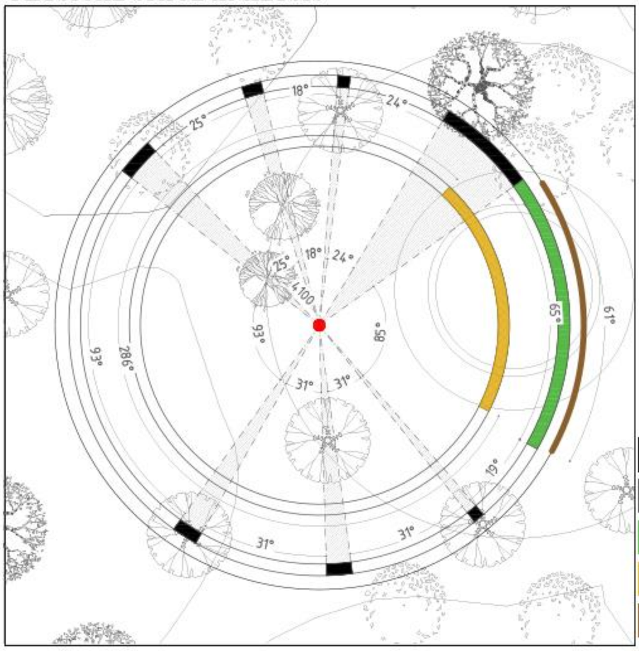
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 15 (L_15)

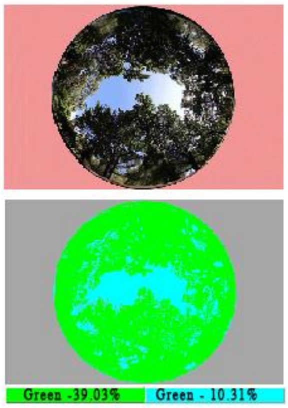
PHYSICAL SPACE ANALYSIS



L_15 is located near to an elevated landscape design located in the central axis of the park. This area is highly used by the users and this is like a central hub to many of the main pathways surrounding the park premises.

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

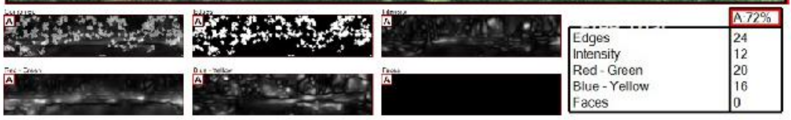
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

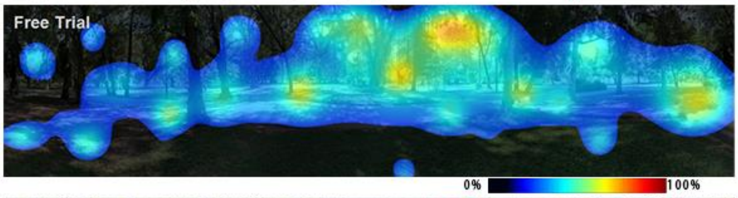
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design



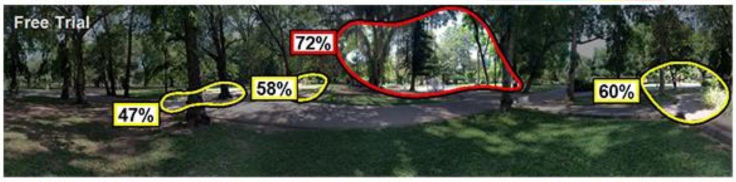
Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.



Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

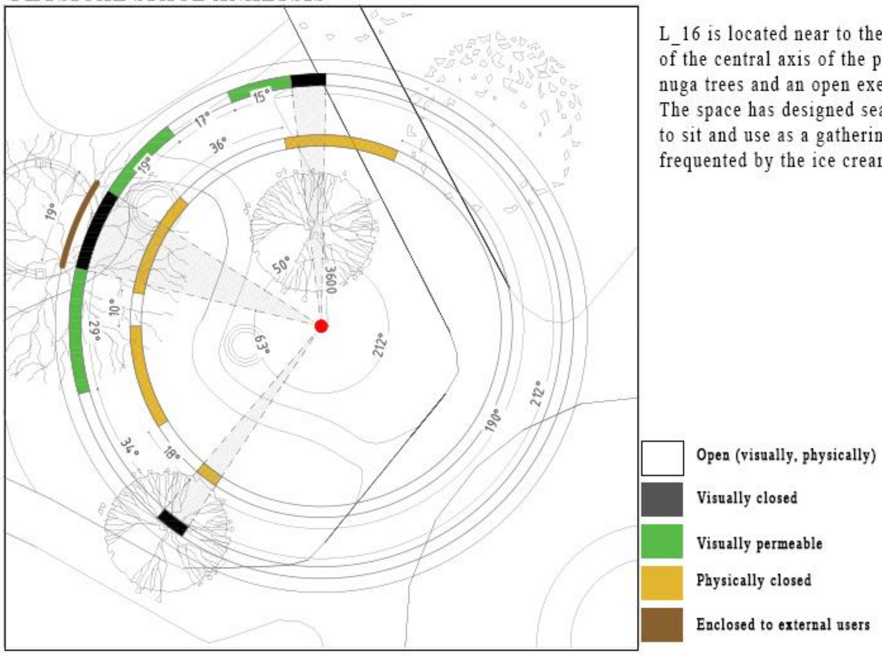
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

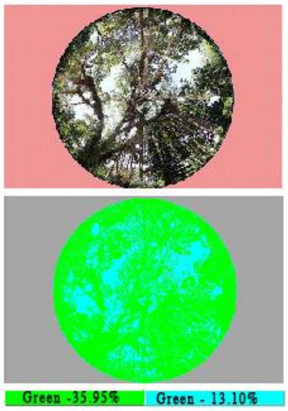
LOCATION _ 16 (L_16)

PHYSICAL SPACE ANALYSIS



L_16 is located near to the elevated landscaped area at the end of the central axis of the park. The space consists of iconic nuga trees and an open exercise area is located adjacent to it. The space has designed seating spaces and podiums for users to sit and use as a gathering space. The space is highly frequented by the ice cream vendors as well.

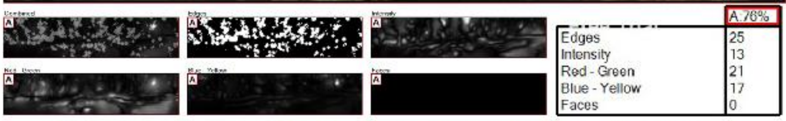
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

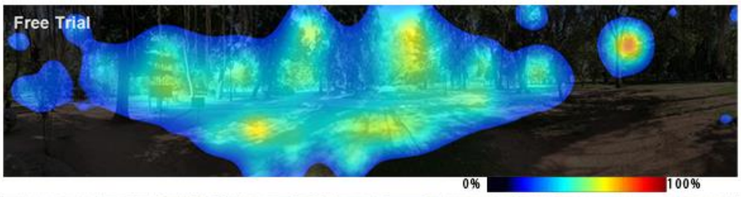
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design



Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.

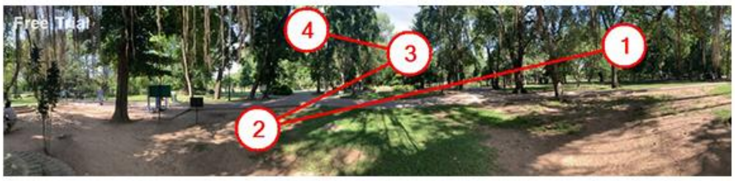


Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.



Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

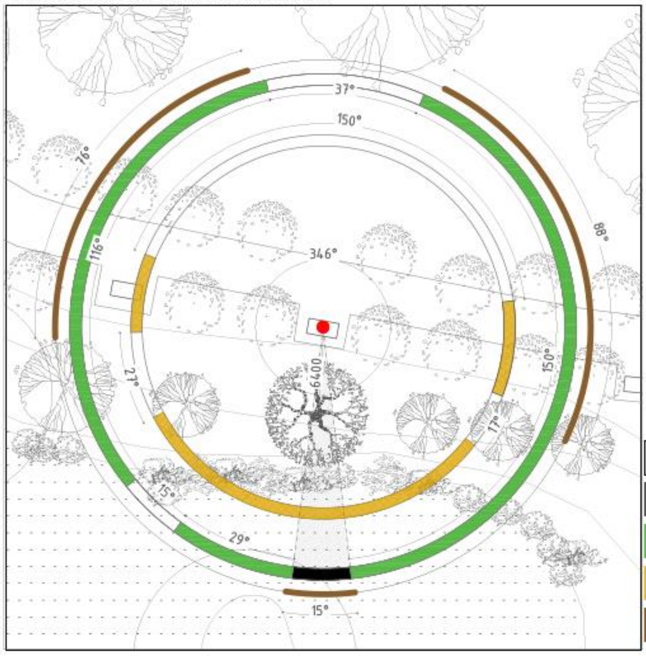
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 17 (L_17)

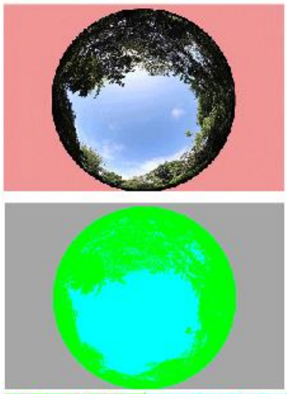
PHYSICAL SPACE ANALYSIS



L_17 is located in the bank of the artificial waterbody inside the park premises. The space is isolated from the other spaces from a medium level plants planted in regular intervals isolating the space between the pathway and the waterbody. This space is highly used as a result of the unique environmental qualities there.

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

DHP ANALYSIS

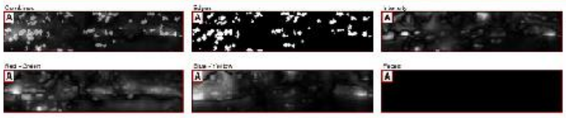


Green -28.48% Green - 21.67%

VISUAL HOTSPOT ANALYSIS

Areas of Interest

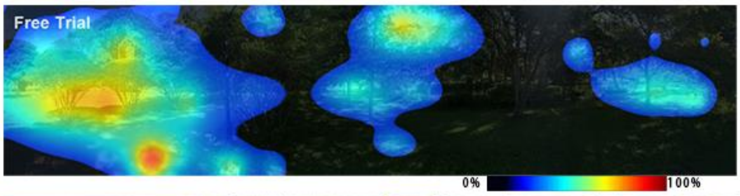
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A:82%
Edges	27
Intensity	14
Red - Green	23
Blue - Yellow	18
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.

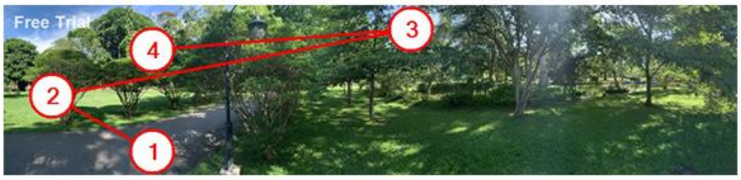


Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.



Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

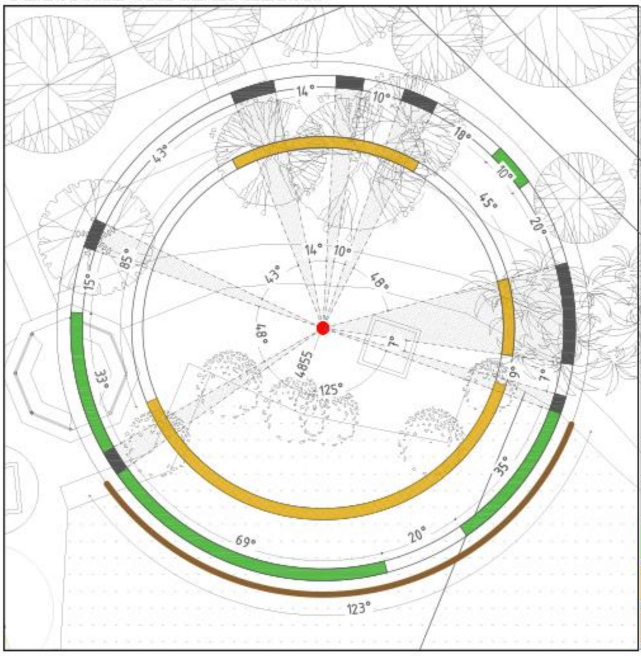
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 18 (L_18)

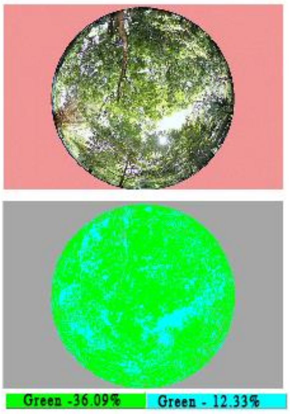
PHYSICAL SPACE ANALYSIS



Open (visually, physically)
Visually closed
Visually permeable
Physically closed
Enclosed to external users

L_18 is also located near the waterbody where there are numerous designed seatings near the space and also a watch hut frequently used by the users. Here all the boat rides and other activities can be easily monitored with the extended views and the space is surveillanced by the other users of the adjacent spaces around.

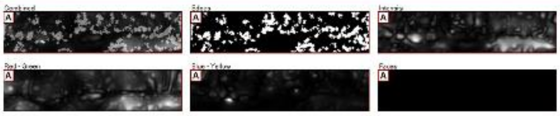
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

Areas of Interest

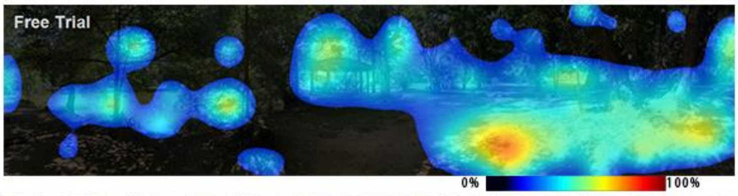
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A:76%
Edges	25
Intensity	13
Red - Green	21
Blue - Yellow	17
Faces	0

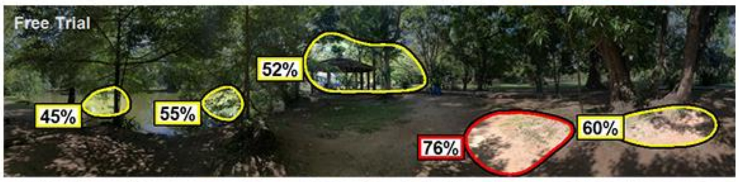
Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.



Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

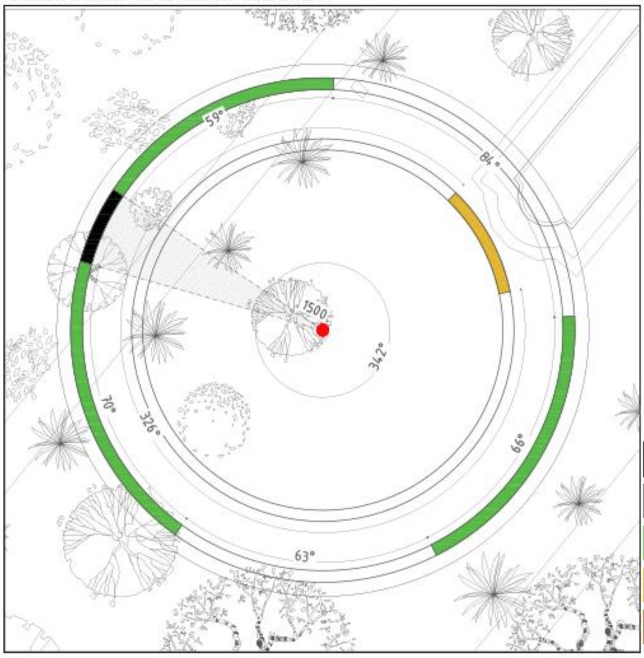
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 19 (L_19)

PHYSICAL SPACE ANALYSIS



L_19 is located in the central axis of the park running through the Buddha statue. This area is extremely open to all the users who take this central pathway. This space is frequently used by the users who enjoy the unique scenery of the park.

Open (visually, physically)
Visually closed
Visually permeable
Physically closed
Enclosed to external users

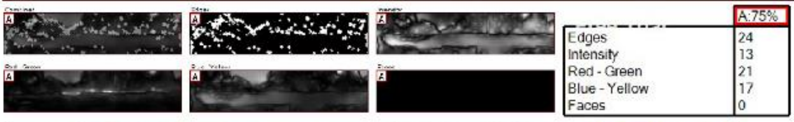
DHP ANALYSIS

Green -25.62% Green - 22.38%

VISUAL HOTSPOT ANALYSIS

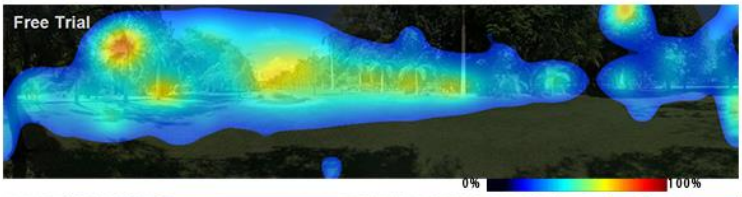
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design



Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

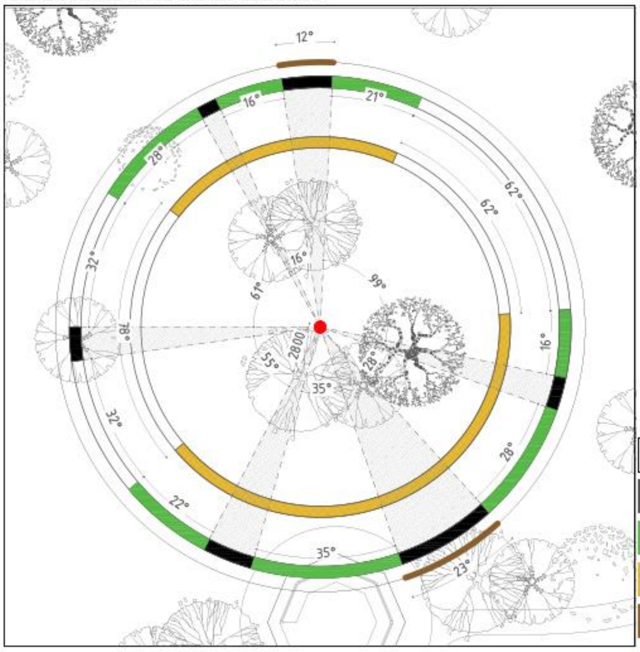
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 20 (L_20)

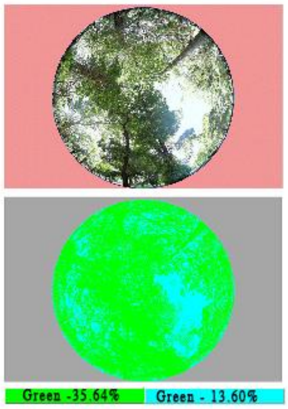
PHYSICAL SPACE ANALYSIS



L_20 is located near to a viewing hut where users frequently used. The space is open to a variety of users in the adjacent areas.

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

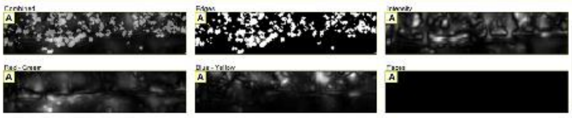
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

Areas of Interest

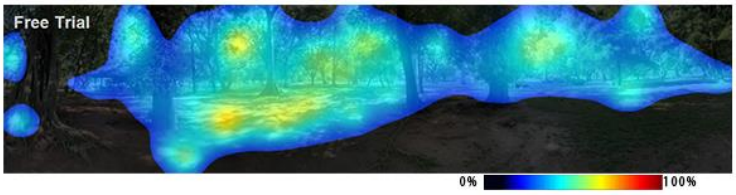
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A:63%
Edges	20
Intensity	11
Red - Green	18
Blue - Yellow	14
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

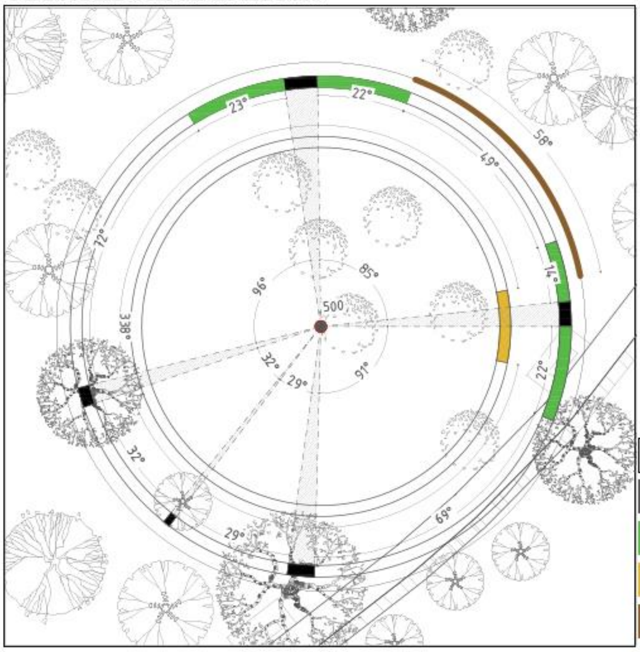
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 21 (L_21)

PHYSICAL SPACE ANALYSIS



L_21 is located near to the green path (which is a major road) facing the National Art Gallery, Nelum pokuna on the other side of the road visible to the park premises. There are users who frequently use this area. But at the daytime the bats are there under some trees in the area. Still the selected space is quite often used by the users as there are designated seatings in the area.

Open (visually, physically)

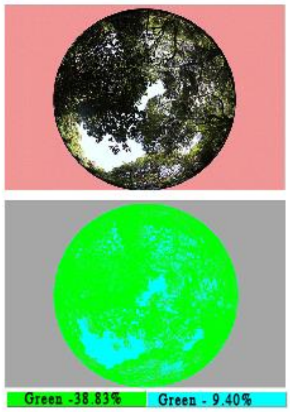
Visually closed

Visually permeable

Physically closed

Enclosed to external users

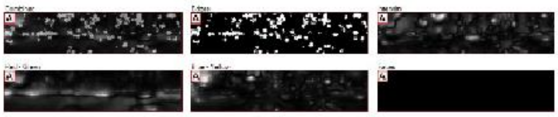
DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

Areas of Interest

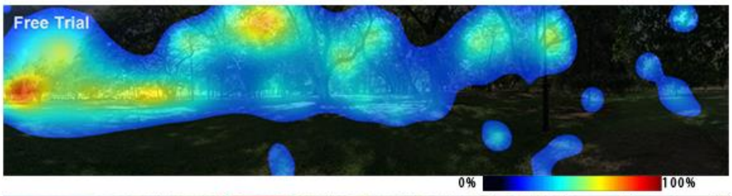
- Provides probability scores on the likelihood specified areas of interest will be seen within the design



	A:80%
Edges	27
Intensity	13
Red - Green	22
Blue - Yellow	18
Faces	0

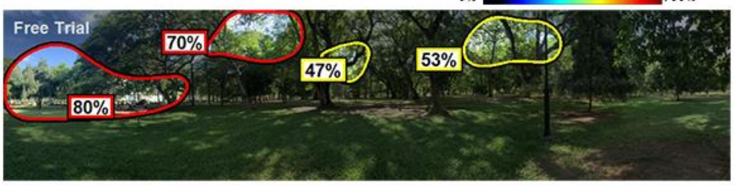
Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.



Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

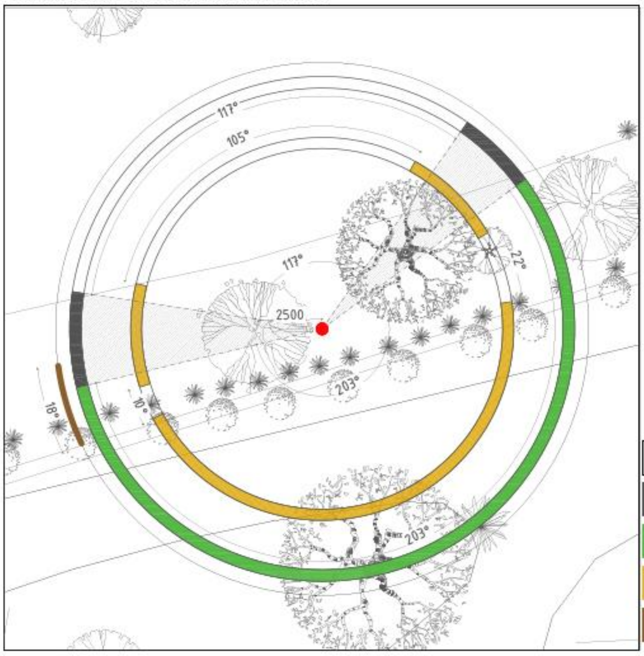
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 22 (L_22)

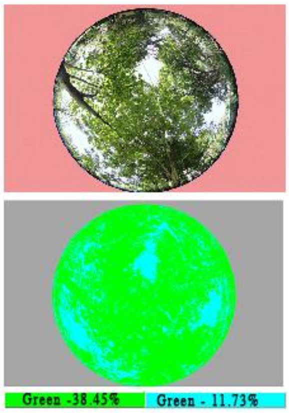
PHYSICAL SPACE ANALYSIS



L_22 is located near the open air theater area which is busy often. This area is famous for its usages of different functions focusing the theater and surrounding area. As a result there are people roaming in the vicinity increasing the eyes on these spaces. There is a major pathway (which is catered for both pedestrians and vehicles) close to this space.

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

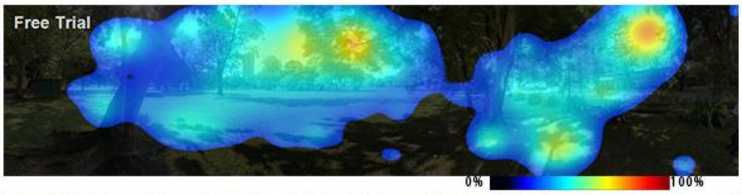
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design

	A:73%
Edges	25
Intensity	12
Red - Green	20
Blue - Yellow	16
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

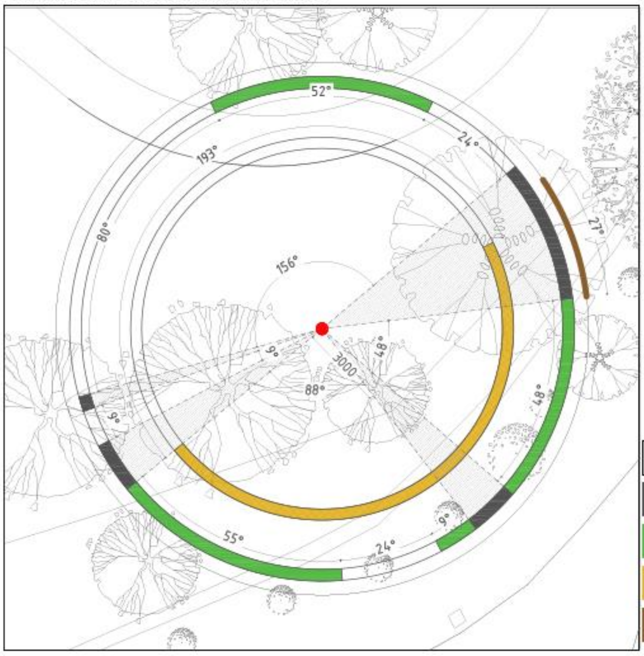
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 23 (L_23)

PHYSICAL SPACE ANALYSIS



- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

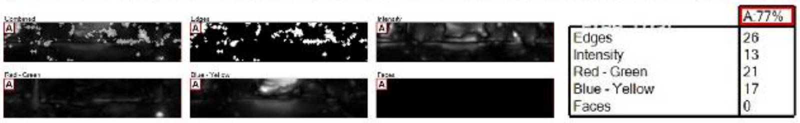
L_23 is also located near the open air theater area which is busy often. This area is famous for its usages of different functions focusing the theater and surrounding area. As a result there are people roaming in the vicinity increasing the eyes on these spaces. There is a major pathway (which is catered for both pedestrians and vehicles) close to this space. There is also a security hut increasing the level of surveillance on the space.

DHP ANALYSIS

VISUAL HOTSPOT ANALYSIS

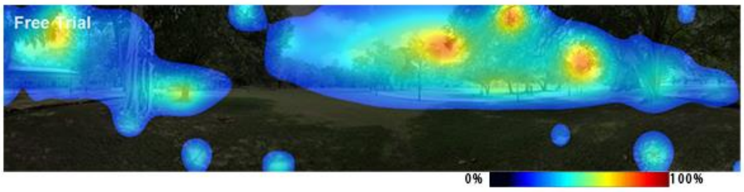
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design



Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

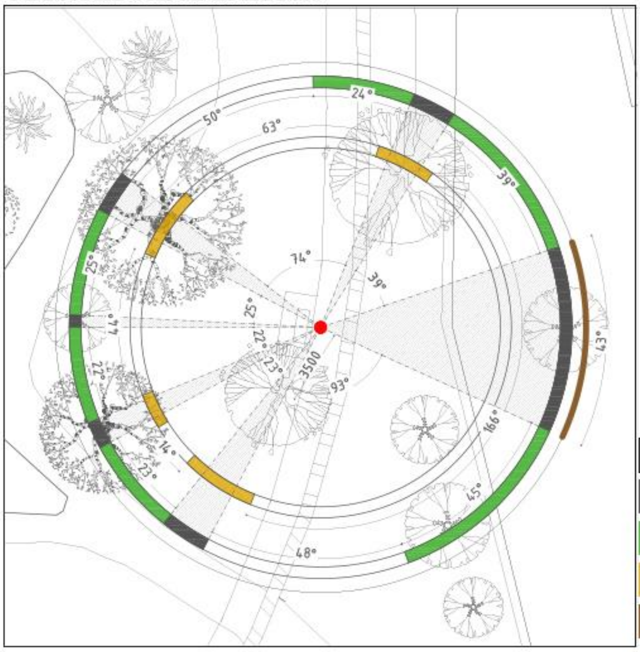
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 24 (L_24)

PHYSICAL SPACE ANALYSIS



L_24 is also located near the open air theater area which is busy often. This location has a designated seating facing the open theater area. The space is frequently used by school children as there are mock traffic setup adjacent to the selected location. Due to its close location to the main road, this space is frequently used by the users.

Open (visually, physically)

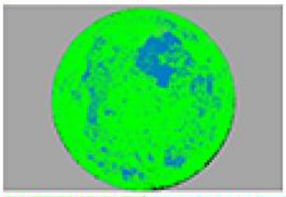
Visually closed

Visually permeable

Physically closed

Enclosed to external users

DHP ANALYSIS



Green -35.30% Green - 14.29%

VISUAL HOTSPOT ANALYSIS

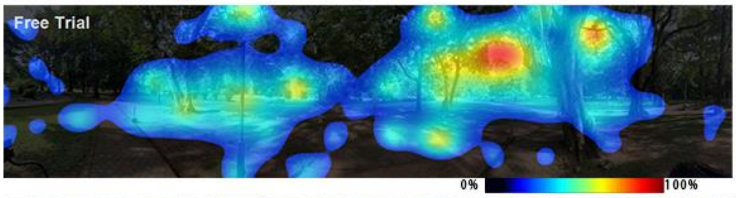
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design

	A:86%
Edges	29
Intensity	14
Red - Green	24
Blue - Yellow	19
Faces	0

Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.

Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.

Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

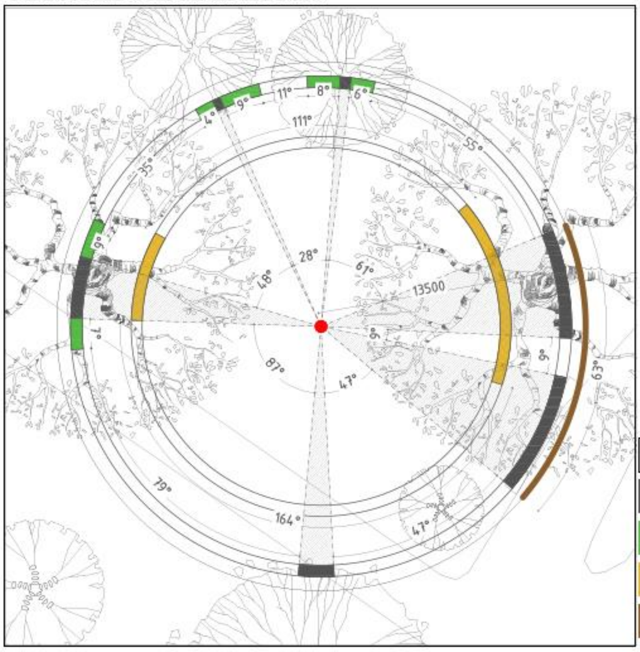
VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

LOCATION _ 25 (L_25)

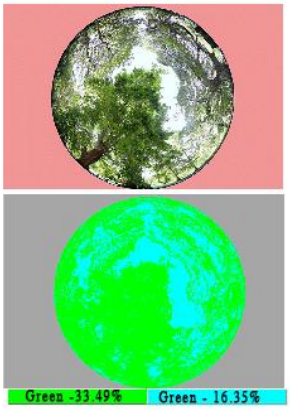
PHYSICAL SPACE ANALYSIS



L_25 is also located near the mock traffic setup. This space is quite close to the canteen as well. Thus, other users can see this space from other waiting spaces. The massive iconic trees of the space enhances the aesthetic quality of the space.

- Open (visually, physically)
- Visually closed
- Visually permeable
- Physically closed
- Enclosed to external users

DHP ANALYSIS



VISUAL HOTSPOT ANALYSIS

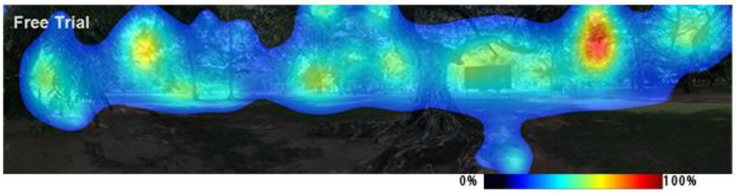
Areas of Interest

- Provides probability scores on the likelihood specified areas of interest will be seen within the design

	A:86%
Edges	29
Intensity	14
Red - Green	24
Blue - Yellow	19
Faces	0

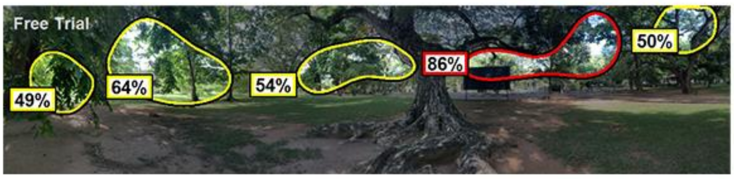
Visual Elements

- Scores the elements our visual systems use to determine attention - edges, color contrasts, intensity, and faces. Data can guide refinements that may strengthen viewer's attraction.



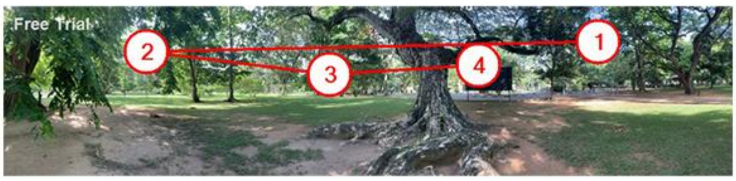
Heatmap

- Probability of visual fixation within 3 - 5 seconds. Provides an easy-to-read visual overview of the salient areas of the design.



Hotspots

- Scores the probability of gaining viewer's attention in the hotspot regions of the heatmap.



Gaze Sequence

- Presents the order a person will view the first 4 areas most likely to be noticed.

VISUAL COMPLEXITY ANALYSIS

Binary Image

- The binary image (with outline) as produced by the Image J software.

Appendix D.2: Summary of the objective qualities of the 25 selected spaces in Vihara Maha Devi park, Colombo

Location	VEG	HP	HP_{area}	HP_{mean}	HP_{mean_w}	HP_{max}	HP_{min}	HP_{max_area}	VE_{edges}	$VE_{intensity}$	$CLR_{red\text{-}green}$	$CLR_{blue\text{-}yellow}$	HP_{veg}	D_{fract}	PAI	DHP_{sky}	DHP_{veg}	D_ENCL	D_EXP	R_SCL	V_DEP	V_PRM	P_ACS
L_01	49.07	2	11.05	65.50	66.86	70	61	7.20	23	12	19	16	88.61	1.8988	0.57	16.05	83.95	18.61	83.89	2.13	3.00	47.64	46.67
L_02	80.45	3	13.14	66.67	79.27	87	49	9.59	29	15	24	19	84.57	1.8954	0.52	22.59	77.41	19.44	82.50	4.25	3.00	49.58	71.67
L_03	66.77	4	16.18	66.00	66.27	81	48	4.33	26	14	23	18	78.88	1.9103	0.57	18.05	81.95	12.22	67.50	3.00	2.00	57.08	8.61
L_04	41.56	4	24.90	62.60	70.41	87	37	7.99	29	15	24	19	67.66	1.8347	0.60	14.34	85.66	14.44	78.06	2.20	3.00	78.19	32.78
L_05	75.37	4	24.45	54.00	59.18	64	39	9.87	28	14	23	18	60.37	1.8913	0.45	31.70	68.30	15.83	65.28	1.83	3.00	62.64	35.00
L_06	58.68	4	12.64	52.75	57.64	66	39	2.28	22	11	18	15	75.60	1.9006	0.53	21.21	78.79	31.39	75.00	0.90	3.00	39.17	51.94
L_07	86.99	5	20.61	58.50	66.09	52	49	3.87	23	11	19	15	85.40	1.8965	0.50	24.40	75.60	13.61	84.17	3.77	1.00	57.50	36.11
L_08	85.51	6	18.41	60.17	63.29	85	46	5.68	28	14	24	19	75.95	1.8940	0.49	27.56	72.44	16.39	83.61	19.40	3.00	79.72	76.94
L_09	79.92	4	24.09	64.25	72.34	77	40	9.81	26	13	21	17	81.52	1.8762	0.54	21.19	78.81	22.78	83.61	2.65	2.00	54.31	55.83
L_10	74.94	6	18.23	60.50	59.45	70	49	4.91	23	12	19	16	60.27	1.8844	0.55	18.92	81.08	21.67	81.67	3.88	2.00	60.14	47.78
L_11	88.12	2	16.85	81.50	83.19	92	71	9.78	31	15	26	20	58.07	1.8820	0.47	28.63	71.37	18.06	4.44	11.00	1.00	40.97	88.89
L_12	99.20	5	15.06	60.60	65.34	87	47	4.92	29	15	24	19	80.48	1.8929	0.46	30.12	69.88	36.67	63.89	1.40	3.00	39.44	54.72
L_13	45.79	2	8.71	62.00	63.66	66	58	6.16	22	11	18	15	66.02	1.8498	0.53	21.05	78.95	24.72	83.89	3.54	1.00	75.28	75.28
L_14	44.71	5	15.28	57.80	58.54	67	44	4.54	23	11	18	15	84.64	1.8806	0.65	10.07	89.93	14.17	87.50	3.60	2.00	74.44	75.28
L_15	77.12	4	15.50	59.25	66.35	72	47	9.89	24	12	20	16	68.92	1.8934	0.54	20.90	79.10	14.72	83.06	5.00	3.00	75.97	79.44
L_16	52.86	3	13.46	66.33	62.75	76	61	1.06	25	13	21	17	65.86	1.8733	0.49	26.71	73.29	9.72	94.72	0.42	3.00	81.81	70.56
L_17	79.37	3	14.02	60.67	73.93	82	40	9.73	27	14	23	18	75.14	1.8593	0.36	43.21	56.79	3.89	50.28	0.50	1.00	55.42	53.89
L_18	50.84	5	14.11	57.60	60.68	76	45	4.28	25	13	21	17	84.04	1.8703	0.50	25.46	74.54	18.06	65.83	0.56	1.00	61.25	38.61
L_19	88.01	4	11.96	64.00	67.73	75	49	4.63	24	13	21	17	80.33	1.8804	0.33	46.63	53.38	5.00	100.00	1.33	3.00	67.92	90.56
L_20	58.07	2	9.93	56.00	55.64	63	49	4.71	20	11	18	14	67.96	1.8864	0.48	27.62	72.38	18.33	90.28	7.14	2.00	58.06	38.89

L_21	83.32	4	16.60	62.50	69.41	80	47	8.18	27	13	22	18	83.61	1.8806	0.55	19.49	80.51	7.50	83.89	9.50	2.00	80.97	93.89
L_22	85.83	3	15.35	65.33	66.93	73	55	3.21	25	12	20	16	60.77	1.8704	0.53	23.38	76.62	11.11	95.00	0.96	3.00	60.69	38.06
L_23	86.34	4	14.33	68.00	70.04	75	53	1.71	26	13	21	17	75.63	1.8921	0.52	24.36	75.64	18.89	92.50	0.83	3.00	60.83	53.61
L_24	57.37	3	19.39	65.67	71.91	86	52	9.61	29	14	24	19	69.13	1.8969	0.48	28.82	71.18	23.33	88.06	2.29	3.00	51.94	79.72
L_25	69.15	5	19.64	60.60	64.04	86	49	4.92	29	14	24	19	82.15	1.8966	0.44	32.80	67.20	22.22	82.50	0.22	2.00	70.69	76.39

VEG	Total area of greens in panoramic landscape photographs (PLPs).	Vegetation	Stimuli based analysis
Hp	Number of HPs in PLPs	Visual hotspots	
HP_{area}	Total area of HPs		
HP_{mean}	Mean probability of HPs		
HP_{mean_w}	Area-weighted mean probability		
HP_{max}	Highest probability of HPs		
HP_{min}	Lowest probability of HPs		
HP_{max_area}	Estimated area of the top-hotspot		
VE_{edges}	Mean contribution of edges in HPs		
$VE_{intensity}$	Mean contribution of intensity in HPs		
$CLR_{red-green}$	Mean contribution of red-green color contrast in HPs		
$CLR_{blue-yellow}$	Mean contribution of blue-yellow color contrast in HPs		
HP_{veg}	Proportion of greens in HPs		
D_{fract}	Fractal dimension coefficient	Visual complexity	
PAI	Plant Area index	Shade levels	
DHP_{sky}	Percentage of sky visibility in DHP		
DHP_{veg}	Percentage of vegetation visibility in DHP		
D_ENCL	Total enclosed arc visually (as a proportion)	Degree of enclosure	Physical Space analysis
D_EXP	Total exposed arc (as a proportion)	Degree of exposure	
R_SCL	Proportion of relative height to width	Relative scale	
V_DEP	Depth of a view	View depth	

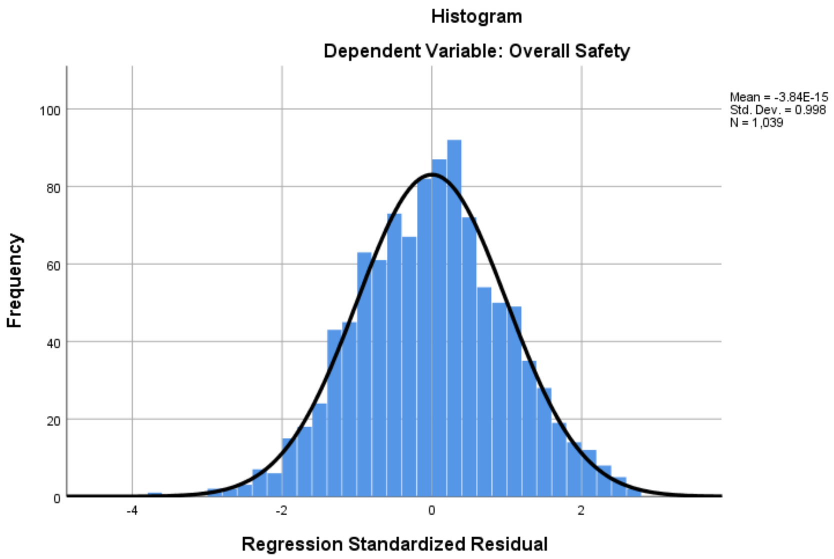
V_PRM	Permeability of the scenery (weighted average)	Visual permeability
P_ACS	Total accessible area (as a proportion)	Physical accessibility

Appendix E: Statistical Analysis results of the Stepwise Regression Analysis

Appendix E.1: Stepwise Regression Analysis - Impact of Visual Hotspots on Sense of Safety and Comfort

<u>Appendix E.1.1: Stepwise Regression Analysis - Impact of Visual Hotspots on Sense of Safety</u>

The Residual plot histogram. In regression it is assumed that the residuals are normally distributed.



Descriptive Statistics of the attributes of the model.

Descriptive Statistics

	Mean	Std. Deviation	N
Overall Safety	4.7096	.7508	1039
HP	3.84	1.141	1039
HP_area	24.532	40.237	1039
HP_min	48.78	7.691	1039
HP_max_area	6.1614	2.7828	1039
HP_veg	74.3979	9.0470	1039

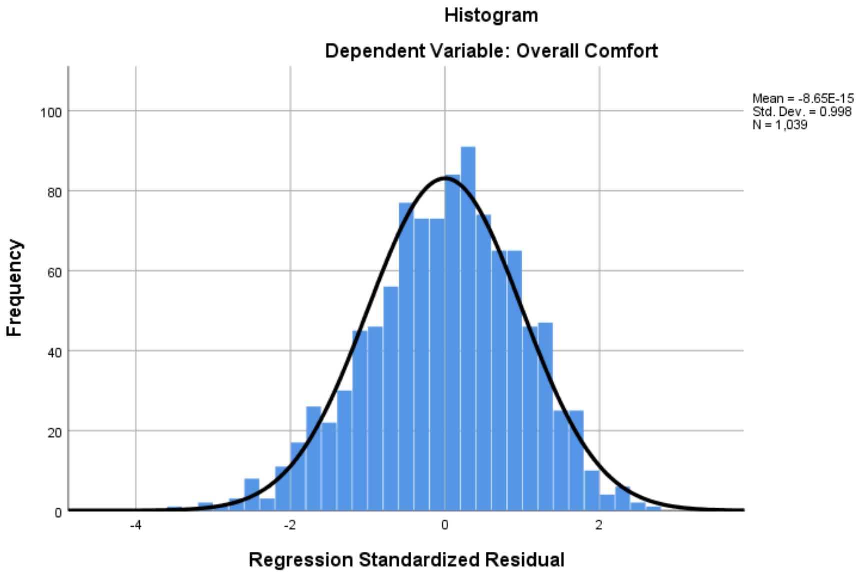
Correlation matrix of the Dependent and independent variables

Correlations

		Overall Safety	HP	HP_area	HP_min	HP_max_area	HP_veg
Pearson Correlation	Overall Safety	1.000	.175	.302	-.588	.040	.074
	HP	.175	1.000	.074	-.510	-.261	.270
	HP_area	.302	.074	1.000	-.309	.315	-.338
	HP_min	-.588	-.510	-.309	1.000	-.149	-.230
	HP_max_area	.040	-.261	.315	-.149	1.000	-.118
	HP_veg	.074	.270	-.338	-.230	-.118	1.000
Sig. (1-tailed)	Overall Safety	.	.000	.000	.000	.096	.009
	HP	.000	.	.009	.000	.000	.000
	HP_area	.000	.009	.	.000	.000	.000
	HP_min	.000	.000	.000	.	.000	.000
	HP_max_area	.096	.000	.000	.000	.	.000
	HP_veg	.009	.000	.000	.000	.000	.

Appendix E.1.1: Stepwise Regression Analysis - Impact of Visual Hotspots on Sense of Comfort

The Residual plot histogram. In regression it is assumed that the residuals are normally distributed.



Descriptive Statistics of the attributes of the model.

Descriptive Statistics

	Mean	Std. Deviation	N
Overall Comfort	5.1643	.63043	1039
HP	3.84	1.141	1039
HP_max	75.83	9.419	1039
HP_min	48.78	7.691	1039
HP_max_area	6.1614	2.7828	1039
VE_edges	25.75	2.758	1039
HP_veg	74.3979	9.04702	1039

Correlation matrix of the Dependent and independent variables

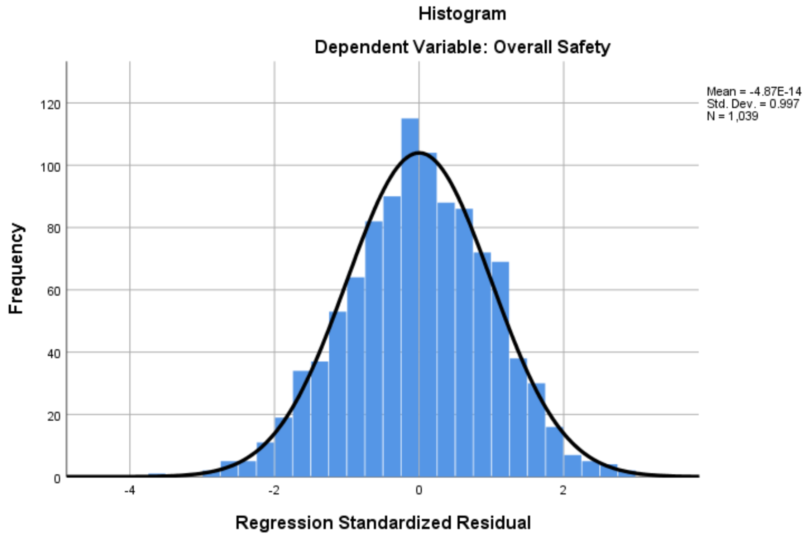
Correlations

		Overall Comfort	HP	HP_max	HP_min	HP_max_area	VE_edges	HP_veg
Pearson Correlation	Overall Comfort	1.000	.100	-.022	-.542	.092	.009	.013
	HP	.100	1.000	-.023	-.510	-.261	.078	.270
	HP_max	-.022	-.023	1.000	.114	.335	.820	-.004
	HP_min	-.542	-.510	.114	1.000	-.149	.007	-.230
	HP_max_area	.092	-.261	.335	-.149	1.000	.477	-.118
	VE_edges	.009	.078	.820	.007	.477	1.000	-.088
	HP_veg	.013	.270	-.004	-.230	-.118	-.088	1.000
Sig. (1-tailed)	Overall Comfort	.	.001	.238	.000	.001	.387	.340
	HP	.001	.	.228	.000	.000	.006	.000
	HP_max	.238	.228	.	.000	.000	.000	.454
	HP_min	.000	.000	.000	.	.000	.406	.000
	HP_max_area	.001	.000	.000	.000	.	.000	.000
	VE_edges	.387	.006	.000	.406	.000	.	.002
	HP_veg	.340	.000	.454	.000	.000	.002	.

Appendix E.2 - Stepwise Regression Analysis - Impact of Vegetation Qualities on the Sense of Safety and Comfort

Appendix E.2.1: Stepwise Regression Analysis - Impact of Vegetation Qualities on the Sense of Safety

The Residual plot histogram



Descriptive Statistics of the attributes of the model.

Descriptive Statistics

	Mean	Std. Deviation	N
Overall Safety	4.709	.750	1039
Fractal Dimension	1.883	.0169	1039
Plant Area Index	.504	.0682	1039
Sky visibility	25.244	8.153	1039
Vegetation visibility	74.755	8.153	1039
Degree of Enclosure	17.153	7.331	1039
Degree of Exposure	77.959	18.572	1039
Relative Scale	3.615	4.126	1039
Visual Depth	2.32	.792	1039
Visual Permeability	61.785	12.641	1039
Physical Accessibility	58.762	21.425	1039

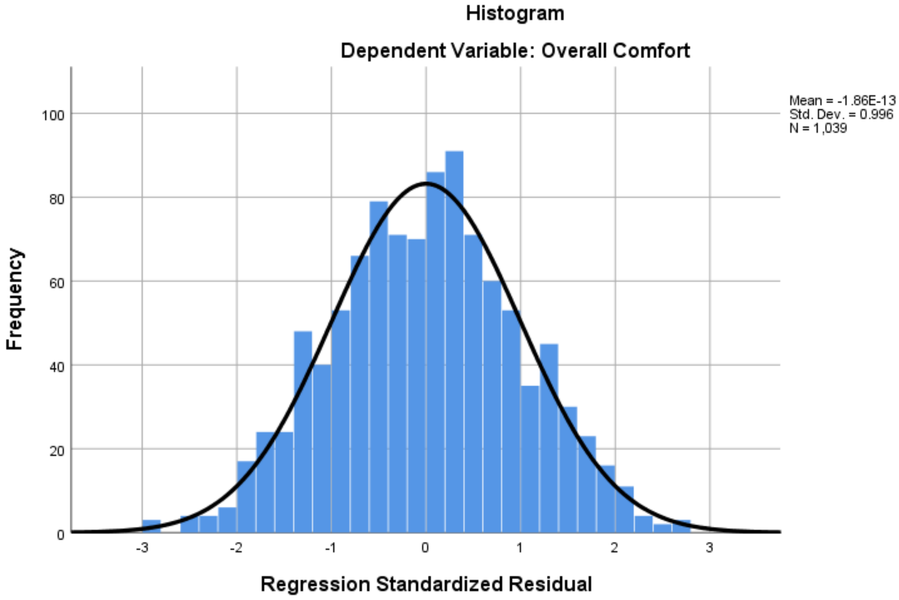
Correlation matrix of the Dependent and independent variables

Correlations

		Overall Safety	Fractal Dimension	Plant Area Index	Sky visibility	Vegetation visibility	Degree of Enclosure	Degree of Exposure	Relative Scale	Visual Depth	Visual Permeability	Physical Accessibility
Pearson Correlation	Overall Safety	1.000	-.142	-.088	.106	-.106	-.099	.201	-.187	.210	.177	-.191
	Fractal Dimension	-.142	1.000	-.030	.013	-.013	.270	.051	.142	.268	-.404	-.003
	Plant Area Index	-.088	-.030	1.000	-.995	.995	.218	.168	.105	.077	.163	-.246
	Sky visibility	.106	.013	-.995	1.000	-1.000	-.257	-.149	-.111	-.054	-.130	.250
	Vegetation visibility	-.106	-.013	.995	-1.000	1.000	.257	.149	.111	.054	.130	-.250
	Degree of Enclosure	-.099	.270	.218	-.257	.257	1.000	-.096	-.069	.126	-.510	-.063
	Degree of Exposure	.201	.051	.168	-.149	.149	-.096	1.000	-.199	.478	.458	.030
	Relative Scale	-.187	.142	.105	-.111	.111	-.069	-.199	1.000	-.064	.211	.345
	Visual Depth	.210	.268	.077	-.054	.054	.126	.478	-.064	1.000	.060	.057
	Visual Permeability	.177	-.404	.163	-.130	.130	-.510	.458	.211	.060	1.000	.256
	Physical Accessibility	-.191	-.003	-.246	.250	-.250	-.063	.030	.345	.057	.256	1.000
Sig. (1-tailed)	Overall Safety	.	.000	.002	.000	.000	.001	.000	.000	.000	.000	.000
	Fractal Dimension	.000	.	.171	.335	.335	.000	.051	.000	.000	.000	.460
	Plant Area Index	.002	.171	.	.000	.000	.000	.000	.000	.007	.000	.000
	Sky visibility	.000	.335	.000	.	.000	.000	.000	.000	.041	.000	.000
	Vegetation visibility	.000	.335	.000	.000	.	.000	.000	.000	.041	.000	.000
	Degree of Enclosure	.001	.000	.000	.000	.000	.	.001	.013	.000	.000	.020
	Degree of Exposure	.000	.051	.000	.000	.000	.001	.	.000	.000	.000	.165
	Relative Scale	.000	.000	.000	.000	.000	.013	.000	.	.020	.000	.000
	Visual Depth	.000	.000	.007	.041	.041	.000	.000	.020	.	.026	.034
	Visual Permeability	.000	.000	.000	.000	.000	.000	.000	.000	.026	.	.000
	Physical Accessibility	.000	.460	.000	.000	.000	.020	.165	.000	.034	.000	.

Appendix E.2.2: Stepwise Regression Analysis - Impact of Vegetation Qualities on the Sense of Comfort

The Residual plot histogram



Descriptive Statistics of the attributes of the model.

Descriptive Statistics

	Mean	Std. Deviation	N
Overall Comfort	5.164	.630	1039
Fractal Dimension	1.883	.0169	1039
Vegetation visibility	74.755	8.153	1039
Degree of Enclosure	17.153	7.331	1039
Degree of Exposure	77.959	18.572	1039
Relative Scale	3.615	4.126	1039
Visual Depth	2.32	.792	1039
Visual Permeability	61.785	12.641	1039
Physical Accessibility	58.762	21.4250	1039

Correlation matrix of the Dependent and independent variables

Correlations

		Overall Comfort	Fractal Dimension	Vegetation visibility	Degree of Enclosure	Degree of Exposure	Relative Scale	Visual Depth	Visual Permeability	Physical Accessibility
Pearson Correlation	Overall Comfort	1.000	-.364	-.241	-.205	.359	-.254	.286	.324	-.048
	Fractal Dimension	-.364	1.000	-.013	.270	.051	.142	.268	-.404	-.003
	Vegetation visibility	-.241	-.013	1.000	.257	.149	.111	.054	.130	-.250
	Degree of Enclosure	-.205	.270	.257	1.000	-.096	-.069	.126	-.510	-.063
	Degree of Exposure	.359	.051	.149	-.096	1.000	-.199	.478	.458	.030
	Relative Scale	-.254	.142	.111	-.069	-.199	1.000	-.064	.211	.345
	Visual Depth	.286	.268	.054	.126	.478	-.064	1.000	.060	.057
	Visual Permeability	.324	-.404	.130	-.510	.458	.211	.060	1.000	.256
	Physical Accessibility	-.048	-.003	-.250	-.063	.030	.345	.057	.256	1.000
Sig. (1-tailed)	Overall Comfort	.	.000	.000	.000	.000	.000	.000	.000	.060
	Fractal Dimension	.000	.	.335	.000	.051	.000	.000	.000	.460
	Vegetation visibility	.000	.335	.	.000	.000	.000	.041	.000	.000
	Degree of Enclosure	.000	.000	.000	.	.001	.013	.000	.000	.020
	Degree of Exposure	.000	.051	.000	.001	.	.000	.000	.000	.165
	Relative Scale	.000	.000	.000	.013	.000	.	.020	.000	.000
	Visual Depth	.000	.000	.041	.000	.000	.020	.	.026	.034
	Visual Permeability	.000	.000	.000	.000	.000	.000	.026	.	.000
	Physical Accessibility	.060	.460	.000	.020	.165	.000	.034	.000	.
N	Overall Comfort	1039	1039	1039	1039	1039	1039	1039	1039	1039
	Fractal Dimension	1039	1039	1039	1039	1039	1039	1039	1039	1039
	Vegetation visibility	1039	1039	1039	1039	1039	1039	1039	1039	1039
	Degree of Enclosure	1039	1039	1039	1039	1039	1039	1039	1039	1039
	Degree of Exposure	1039	1039	1039	1039	1039	1039	1039	1039	1039
	Relative Scale	1039	1039	1039	1039	1039	1039	1039	1039	1039
	Visual Depth	1039	1039	1039	1039	1039	1039	1039	1039	1039
	Visual Permeability	1039	1039	1039	1039	1039	1039	1039	1039	1039
	Physical Accessibility	1039	1039	1039	1039	1039	1039	1039	1039	1039

Appendix E.3 - Curve estimation results of PAI (shade levels), Vegetation visibility and Degree of Exposure with overall safety

Model Summary and Parameter Estimates

Dependent Variable: Overall Safety

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.008	8.164	1	1037	.004	5.200	-.972		
Logarithmic	.009	9.453	1	1037	.002	4.370	-.489		
Inverse	.010	10.208	1	1037	.001	4.246	.229		
Quadratic	.014	7.173	2	1036	.001	6.973	-8.484	7.780	
Cubic	.014	7.552	2	1036	.001	6.467	-4.986	.000	5.606
Compound	.004	3.954	1	1037	.047	5.029	.853		
Power	.005	5.184	1	1037	.023	4.376	-.085		
S	.006	6.196	1	1037	.013	1.451	.042		
Growth	.004	3.954	1	1037	.047	1.615	-.159		
Exponential	.004	3.954	1	1037	.047	5.029	-.159		
Logistic	.004	3.954	1	1037	.047	.199	1.172		

The independent variable is Plant Area Index.

Model Summary and Parameter Estimates

Dependent Variable: Overall Safety

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.011	11.799	1	1037	.001	5.440	-.010		
Logarithmic	.012	12.705	1	1037	.000	7.760	-.708		
Inverse	.013	13.210	1	1037	.000	4.041	49.321		
Quadratic	.015	7.858	2	1036	.000	7.753	-.076	.000	
Cubic	.015	8.136	2	1036	.000	7.101	-.045	.000	2.298E-6
Compound	.006	6.758	1	1037	.009	5.286	.998		
Power	.007	7.772	1	1037	.005	8.129	-.130		
S	.008	8.574	1	1037	.003	1.409	9.327		
Growth	.006	6.758	1	1037	.009	1.665	-.002		
Exponential	.006	6.758	1	1037	.009	5.286	-.002		
Logistic	.006	6.758	1	1037	.009	.189	1.002		

The independent variable is Vegetation visibility.

Model Summary and Parameter Estimates

Dependent Variable: Overall Safety

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.040	43.723	1	1037	.000	4.076	.008		
Logarithmic	.159	196.197	1	1037	.000	2.493	.519		
Inverse	.238	323.941	1	1037	.000	4.896	-8.951		
Quadratic	.305	227.448	2	1036	.000	2.645	.079	-.001	
Cubic	.382	213.521	3	1035	.000	1.942	.211	-.004	1.834E-5
Compound	.085	96.105	1	1037	.000	3.744	1.003		
Power	.238	324.716	1	1037	.000	2.459	.149		
S	.326	501.004	1	1037	.000	1.586	-2.452		
Growth	.085	96.105	1	1037	.000	1.320	.003		
Exponential	.085	96.105	1	1037	.000	3.744	.003		
Logistic	.085	96.105	1	1037	.000	.267	.997		

The independent variable is Degree of Exposure.

Appendix E.4 - Curve estimation results of PAI (shade levels) and Sky visibility with overall Comfort

Model Summary and Parameter Estimates

Dependent Variable: Overall Comfort

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.045	48.630	1	1037	.000	6.149	-1.954		
Logarithmic	.054	59.399	1	1037	.000	4.466	-1.005		
Inverse	.063	69.950	1	1037	.000	4.174	.489		
Quadratic	.080	45.131	2	1036	.000	9.811	-17.461	16.061	
Cubic	.080	45.131	2	1036	.000	9.811	-17.461	16.061	.000
Compound	.034	36.860	1	1037	.000	6.133	.700		
Power	.042	45.748	1	1037	.000	4.503	-.185		
S	.050	54.666	1	1037	.000	1.449	.091		
Growth	.034	36.860	1	1037	.000	1.814	-.357		
Exponential	.034	36.860	1	1037	.000	6.133	-.357		
Logistic	.034	36.860	1	1037	.000	.163	1.429		

The independent variable is Plant Area Index.

Model Summary and Parameter Estimates

Dependent Variable: Overall Comfort

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.058	64.110	1	1037	.000	4.693	.019		
Logarithmic	.040	42.740	1	1037	.000	3.938	.386		
Inverse	.023	24.909	1	1037	.000	5.435	-6.144		
Quadratic	.088	50.121	2	1036	.000	5.522	-.045	.001	
Cubic	.095	36.390	3	1035	.000	4.489	.089	-.004	6.123E-5
Compound	.046	50.175	1	1037	.000	4.693	1.003		
Power	.031	32.860	1	1037	.000	4.088	.071		
S	.018	18.869	1	1037	.000	1.683	-1.120		
Growth	.046	50.175	1	1037	.000	1.546	.003		
Exponential	.046	50.175	1	1037	.000	4.693	.003		
Logistic	.046	50.175	1	1037	.000	.213	.997		

The independent variable is Sky visibility.

Appendix F: Questionnaire for the experts

A STUDY ON THE IMPACT OF VEGETATION CONFIGURATIONS ON THE SENSE OF SAFETY AND COMFORT IN URBAN GREEN SPACES.

I am an MPhil student (Reg. 198124F) from the Faculty of Graduate Studies, University of Moratuwa who is currently undertaking 'A Study on 'Assessing the impact of Vegetation Configurations on the Sense of Safety and Comfort in Urban Green Spaces'. Accordingly, you are kindly invited to participate in this study by providing your **expert opinion** based on the following criteria.

Imagine you are resting at a park covered in trees, plants and and other means of vegetation. A surveyor would come to you and ask some problems related to the level of sense of safety and comfort in the space. This means the Psychological aspects of safety and comfort, not the physical aspects. The feeling of safety irrespective of the physical conditions. Please consider the feeling of safety and comfort irrespective of the actual safety and comfort.

Some phrases for this **evaluation of sense of safety and comfort in green spaces of Sri Lanka** is provided below. With your expertise, provide your opinion on how important the following phrases are for determining the levels of sense of safety and comfort.

* Indicates required question

1. Provide responses for all the below sentences *

Mark only one oval per row.

	1 - Not at all Important	2 - Not so Important	3 - Somewhat Important	4 - Moderately Important	5 - Important	6 - Very Important	7 - Extremely Important
(V1) I feel elated looking at the surrounding	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V2) I feel relaxed looking at the surrounding	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V3) I feel concentrated in this space	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V4) It's calm and quiet (comparatively) here	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V5) I feel attentive to my surrounding	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V6) I prefer what I see here	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V7) I am interested in the scenes from this space	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V8) I would like to stay here longer	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V9) I would visit this place again	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V10) The scenery has fascinating qualities	⬭	⬭	⬭	⬭	⬭	⬭	⬭

2. Provide responses for all the below sentences *

Mark only one oval per row.

	1 - Not at all Important	2 - Not so Important	3 - Somewhat Important	4 - Moderately Important	5 - Important	6 - Very Important	7 - Extremely Important
(V11) I enjoy being here	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V12) I feel energetic being in this place	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V13) I feel pleasant spending time here	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V14) I feel cheerful looking at the sceneries	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V15) What I see here is more attractive	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V16) I feel connected with this space	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V17) I am satisfied with what I see in this space	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V18) I can freely enjoy myself here	⬭	⬭	⬭	⬭	⬭	⬭	⬭

3. Provide responses for all the below sentences *

Mark only one oval per row.

	1 - Not at all Important	2 - Not so Important	3 - Somewhat Important	4 - Moderately Important	5 - Important	6 - Very Important	7 - Extremely Important
(V19) I forget all the problems when I am here	◯	◯	◯	◯	◯	◯	◯
(V20) My mental fatigue keeps decreasing when I am here	◯	◯	◯	◯	◯	◯	◯
(V21) I feel refreshing to be here despite the thermal conditions	◯	◯	◯	◯	◯	◯	◯
(V22) I would love to explore and discover more in this space	◯	◯	◯	◯	◯	◯	◯
(V23) My eyes are not tired at all	◯	◯	◯	◯	◯	◯	◯
(V24) My breathing is effortless in this space	◯	◯	◯	◯	◯	◯	◯
(V25) My heart rate is steady	◯	◯	◯	◯	◯	◯	◯
(V26) I feel confident to do what I like here	◯	◯	◯	◯	◯	◯	◯

4. Provide responses for all the below sentences *

Mark only one oval per row.

	1 - Not at all Important	2 - Not so Important	3 - Somewhat Important	4 - Moderately Important	5 - Important	5 - Very Important	7 - Extremely Important
(V27) I feel comfortable expressing myself in this space	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V28) I feel like people in this space would try their best to help me	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V29) I feel accepted by other users	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V30) I don't feel intimidated by the other users	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V31) I didn't feel judged by others	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V32) My body felt relaxed	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V33) I feel there are no threats in the surrounding	⬭	⬭	⬭	⬭	⬭	⬭	⬭
(V34) I feel harmless in this space	⬭	⬭	⬭	⬭	⬭	⬭	⬭

5. If you feel anything additiol needs to be input in the above phrases, feel free to add those here.

Thank you so much for your valuable time

All your responses will be used only for the Academic purposes only

This content is neither created nor endorsed by Google.

Google Forms

Appendix G: Questionnaire for the Onsite and Online users

QUESTIONNAIRE SURVEY

I am an MPhil student (Reg. 198124F) from the Faculty of Graduate Studies, University of Moratuwa who is currently undertaking 'A Study on 'Assessing the impact of Vegetation Configurations on the Sense of Safety and Comfort in Urban Green Spaces'. Accordingly, you are kindly invited to participate in this study by providing your opinion based on the space you are at the Viharamahadevi Park, Colombo. ***(Please ✓ your choices)***

1. Gender (ස්ත්‍රී පුරුෂ භාවය)	Male (පුරුෂ)		Female (ස්ත්‍රී)		Other (වෙනත්)	

2. Age (වයස)	17 years old or younger (වයස අවුරුදු 17 හෝ ඊට අඩු)	
	18 – 25 year old (වයස අවුරුදු 18 - 25 යි)	
	26 – 35 years old (වයස අවුරුදු 26 – 35)	
	36 – 45 years old (වයස අවුරුදු 36-45)	
	46 – 55 years old (වයස අවුරුදු 46-55)	
	55 years old or above (වයස අවුරුදු 55 හෝ ඊට වැඩි)	

3. Reasons for choosing the park (මෙම උද්‍යානය තෝරා ගැනීමට හේතු)	It is the closest park to me (එය මට සමීපතම උද්‍යානයයි)	
	It has more green compared to other parks (අනෙකුත් උද්‍යානවලට සාපේක්ෂව එහි කොළ පැහැය වැඩියි)	
	I personally like Viharamahadevi park (මම පෞද්ගලිකව විහාරමහාදේවි උද්‍යානයට කැමතියි)	
	This park is iconic (මෙම උද්‍යානය සංකේතාත්මකයි)	
	It has more facilities (එහි වැඩි පහසුකම් ඇත)	
	Other (වෙනත්)	

4. Reasons for chosing the space (මෙම ස්ථානය තෝරා ගැනීමට හේතු)	It has more green (එහි කොළ පැහැය වැඩියි)	
	It is close to the water body (එය ජලයට ආසන්නයි)	
	It has a seating (එහි ආසනයක් ඇත)	
	I like the views from this space (මෙම ස්ථානයේ දසුන් වලට කැමතියි)	
	I feel safe and comfortable here (මෙහි ආරක්ෂාව සහ සුවපහසුව දැනෙනවා)	
	Other (වෙනත්)	

While answering the following section, consider your feelings about the space you are at and provide your genuine scores based on your experience of the space. (පහත කොටසට පිළිතුරු දෙන විට, ඔබ සිටින ස්ථානය පිළිබඳ ඔබේ හැඟීම් සලකා බලා ඔබේ අත්දැකීම් මත පදනම්ව ලකුණු ලබා දෙන්න.)
(Please ✓ your choices)

	Strongly Disagree (දැඩි ලෙස එකඟ නොවේ)	Disagree (එකඟ නොවේ)	Slightly Disagree (තරමක් එකඟ නොවේ)	Neutral (මධ්‍යස්ථයි)	Slightly Agree (තරමක් එකඟ වේ)	Agree (එකඟ වේ)	Strongly Agree (දැඩි ලෙස එකඟ වේ)
I feel pleasant spending time here (මෙහි කාලය ගත කිරීම මට සතුටක් ගෙනදෙනවා)							
I feel energetic being in this place (මෙම ස්ථානයේ සිටීම මට ජවසම්පන්න බවක් ගෙනදෙනවා)							
I enjoy being here (මෙහි සිටීම මට සතුටක්)							
I feel cheerful looking at the sceneries (දසුන් දෙස බලන විට මට ප්‍රීතිමත් බවක් දැනේ)							
What I see here is more attractive (මම මෙහි දකින දේ වඩාත් ආකෂර්ණීයයි)							
My breathing is effortless in this space (මට මේ ස්ථානයේ ආයාසයකින් තොරව හුස්ම ගන්න පුළුවන්)							
My eyes are not tired at all (මෙහි දසුන් දකිද්දී මගේ දැස් සැහැල්ලුය)							
My heart rate is steady (මගේ හෘද ස්පන්දනය ස්ථාවරයි)							
I prefer what I see here (මම මෙහි දකින දේට කැමතියි)							
I am interested in the scenes from this space (මම මෙම ස්ථානයේ දශර්න ගැන උනන්දු වෙමි)							
I feel attentive to my surrounding (මට මගේ වටපිටාව ගැන අවධානයෙන් සිටින බවක් දැනේ)							
I would like to stay here longer (මම මෙහි වැඩි කාලයක් රැඳී සිටීමට කැමතියි)							
I would visit this place again (මම නැවත මෙම ස්ථානයට පැමිණෙමි)							
I don't feel intimidated by the other users (මෙහි සිටින මිනිසුන් ගැන මට බියක් දැනෙන්නේ නැත)							
I feel accepted by other users (මම වෙනත් මිනිසුන් විසින් පිළිගත් බව හැඟේ)							
I didn’t feel judged by others (මට අන් අය විසින් විනිශ්චය කරන බවක් දැනුනේ නැත)							
My mental fatigue keeps decreasing when I am here (මම මෙහි සිටින විට මගේ මානසික විඩාව අඩු වේ)							
I forget all the problems when I am here (මෙහි සිටින විට ප්‍රශ්න ඔක්කොම අමතක වේ)							

Please mention if you have any additional comments (ඔබට අමතර අදහස් ඇත්නම් සදහන් කරන්න)

Thank you for your valuable time!!!!