

**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

Declaration	i
Dedication	ii
Acknowledgement.....	iii
Abstract	iv
Table of Contents	v
List of Figures	viii
List of Tables.....	x
List of Abbreviations.....	xii
List of Appendices	xiii
Chapter 1	1
Introduction	1
1.1 Background	1
1.2 Research Problem.....	2
1.3 Research Questions	3
1.4 Research Aim and Objectives	3
1.5 Research Method	3
1.6 Scope and Limitations of the Research	4
1.7 Research Significance	5
Chapter 2	6
Literature review	6
2.1 Sense of Safety and comfort.....	6
2.1.1 Factors Associated with Sense of Safety and Comfort	7
2.1.2 Sense of Safety and comfort with Environmental Factors.....	8
2.1.3 Vegetation Configurations and Sense of safety and Comfort.....	9
2.2 Theoretical Background	10
2.2.1 Gestalt Psychology	10
2.2.2 Prospect and Refuge Theory	10
2.2.3 Information Processing Theory.....	11

2.2.4	Permeability Theory	12
2.2.5	Attention Restoration Theory	14
2.2.6	Polyvagal Theory	14
2.3	Research Gap identified through Literature Review	15
2.4	Conceptual Framework	17
2.4.1	PHASE I – Exploring the variables for assessment of sense of safety and comfort in urban green spaces.....	18
2.4.2	PHASE II – Identifying the attributes of vegetation configurations which impacts on sense of safety and comfort.....	19
Chapter 3		22
Research methodology		22
3.1	Research Philosophy	22
3.2	Research Design	22
3.2.1	Methodological Choice	22
3.2.2	Research Strategy	23
3.3	Techniques and Procedures of Data Collection – PHASE I.....	24
3.3.1	Focus Group Discussion	25
3.3.2	Principal Component Analysis (PCA)	26
3.4	Techniques and Procedures of Data Collection – PHASE II	26
3.4.1	Stimuli based Analysis.....	27
3.4.2	Physical Space Analysis.....	32
3.4.3	Case Study selection – Phase II	38
3.4.4	Sample Selection – Phase II.....	40
Chapter 4		43
Data analysis and results		43
4.1	Results of Principal Component Analysis – Phase I	43
4.1.1	Introduction	43
4.1.2	Data set Description	43
4.1.3	Eigenvalues and Explained Variances	45
4.1.4	Principal Components and Loadings	46

4.1.5	Interpreting Principal Components	47
4.1.6	Visualization	50
4.1.7	Limitations and Assumptions.....	50
4.1.8	Advancing with PCA results.....	50
4.1.9	Developed Self-assessment tool for assessing the sense of safety and comfort levels in urban green spaces	53
4.2	Objective Analysis of the Qualities of Selected Cases.....	55
4.3	Analysis of the Subjective Data collected.	55
4.3.1	Analysis of Sense of Safety and Comfort based on the Respondent Category	55
4.3.2	Analysis of Sense of Safety and Comfort based on the Gender.	57
4.3.3	Analysis of Sense of Safety and Comfort based on the Age.....	58
4.4	Assessing the Impact of Vegetation Configurations on the Sense of Safety and Comfort	58
4.4.1	Impact of Visual Hotspots on Sense of Safety and Comfort	58
4.4.2	Impact of Vegetation Qualities on the Sense of Safety and Comfort	61
4.5	Sense of Safety and Comfort in the selected locations of the Vihara Maha Devi Park.....	72
4.6	Summary of Findings	74
Chapter 5		77
Conclusion		77
5.1	Limitations of the Study	80
5.2	Future Recommendations.....	81
References		83

LIST OF FIGURES

Figure	Description	Page
Figure 2.1	Point 6.7 in this picture is identified as an occluding chord Source: Stamps (2005)	viii
Figure 2.2	Radial variance and skew change with the location of an observer (Stamps, 2005)	14
Figure 2.3	Article Distribution by the publication year (L. Kawshalya et al., 2020).	16
Figure 2.4	Network visualization of the Journals by VOSViewer software (L. Kawshalya et al., 2020).	16
Figure 2.5	Explored Current Research Trends and its impact on the current literature (L. Kawshalya et al., 2020).	17
Figure 2.6	The two main phases of research process	18
Figure 2.7	The selected attributes relevant to the sky plane, vertical plane and ground plane	21
Figure 3.1	Multi-phase research methodology incorporated into the study	23
Figure 3.2	Case study categorization, (Yin 2018)	234
Figure 3.3	Process of development of the self-assessment tool for examining levels of sense of safety and comfort in urban green spaces	24
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.	29
Figure 3.5	The outputs produced by the 3M VAS software	30
Figure 3.6	(1) Processed DHP images and mask (2) classification results of the final output DHP images.	32
Figure 3.7	Selected 25 case study locations for the study.	39
Figure 3.8	A summary on the data collection procedures and methods used in this study.	41
Figure 3.9	Summary of the research design as developed by the Author.	42

Figure 4.1	The selected 34 variables (through focus group discussions) for the Principal Component Analysis	434
Figure 4.2	Scree plot of the PCA analysis output	46
Figure 4.3	Illustration of the summary of interpretation of the principal components extracted through PCA	489
Figure 4.4	(1) Biplot with all 34 variables (2) Bi plot with only the 18 selected variables after performing PCA	50
Figure 4.5	(1) PLP of highest Dfract. (2) Binary image of highest Dfract as produced by ImageJ (2) PLP of lowest Dfract (4) Binary image of lowest Dfract as produced by Image J.	66
Figure 4.6	The change in R_SCL with changing H/W ratio	677
Figure 4.7	A location with equal proportions of enclosed, permeable and open qualities.	688
Figure 4.8	The changes in D_ENCL and V_PRM explained with respect to the data set	699
Figure 4.9	Sense of Safety and Sense of Comfort levels at the 25 selected locations in Vihara Maha Devi Park.	73

LIST OF TABLES

Table	Description	Page
Table 2.1	Informational variables of Information Processing Theory by Kaplan and Kaplan (1989)	12
Table 1.2	The attributes selected and the respective sources of citation.	20
Table 3.1	Selected variables after the focus group discussion.	25
Table 3.2	The attributes analysed through the outputs produced by the software 3M-VAS (Schirpke et al., 2018)	31
Table 3.3	The methods of measurements for the selected attributes under physical space analysis	35
Table 4.1	The eigenvalues and the total variance explained by the components.	45
Table 4.2	Factor loadings based on PCA with Oblimin rotation ,N=174	47
Table 4.3	An example of the pattern matrix produced by SPSS	51
Table 4.4	An example of calculating the weights for each component (adjusted variance explained)	52
Table 4.5	Developed self-assessment tool for assessing sense of safety and comfort levels in urban green spaces	544
Table 4.6	The descriptives of the different respondent categories for the 6 principal components	566
Table 4.7	The descriptives of the difference between gender for the 6 principal components	577
Table 4.8	Output of the stepwise linear regression on the attributes of Hotspot analysis with the overall safety score.	59
Table 4.9	Output of the stepwise linear regression on the attributes of Hotspot analysis with the overall comfort score.	600
Table 4.10	Summary of the impact of hotspot attributes on the sense of safety and sense of comfort of the users	60
Table 4.11	Correlation coefficients of the Vegetation qualities and Final safety and comfort scores	633

Table 4.12	Output of the stepwise linear regression on the attributes of qualities of vegetation configurations with the overall safety score	644
Table 4.13	Output of the stepwise linear regression on the attributes of qualities of vegetation configurations with the overall comfort score	644
Table 4.14	Summary of the impact of vegetation qualities on the sense of safety and sense of comfort of the users	655
Table 4.15	Minimum and maximum values for the D_ENCL and V_PRM	688
Table 4.16	Summary of the tests performed	711

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

Appendix A: Scales used for assessment psychological constructs of safety and comfort	101
Appendix B: Outputs of Principal Component Analysis	106
Appendix C: Interpretation of the 6 Principal Components.....	112
Appendix D: Vegetation configuration Qualities	116
Appendix E: Statistical Analysis results of the Stepwise Regression Analysis.....	145
Appendix F: Questionnaire for the experts	153
Appendix G: Questionnaire for the Onsite and Online users.....	159