

AN INVESTIGATION INTO THE RELATIONSHIP BETWEEN VISUAL GREENERY OF URBAN CANAL ENVIRONMENT AND EMOTIONAL WELL-BEING OF TEENAGERS IN LOW-INCOME SETTLEMENTS

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Abstract: Urban canal areas, especially in low-income settlements, frequently suffer from inadequate design, which affects the emotional health of teenagers, a demographic that is especially vulnerable to emotional challenges. This study explores how design parameters, such as the density of visual greenery, spatial greenery distribution, and blue-green integration along canal waterfronts, can influence eudaemonic and hedonic emotional well-being and the quality of life for teenagers in these areas. The study, conducted with 40 teenagers living in low-income settlements near canal environments, examined five visual scenarios with varying green coverage ratios (low and high) and greenery distribution (continuous and patchy) using 3D simulations and virtual methods to enhance participants' understanding. High outdoor greenery, regardless of distribution type, is more beneficial than low greenery. The best scenario for psychological well-being is high greenery with a continuous distribution, resulting in very high well-being levels. This setup fosters self-satisfaction, positive feelings, optimism, vitality, and autonomy, affecting both hedonic and eudaemonic well-being. In contrast, conditions with no greenery are the least beneficial. These findings offer valuable recommendations for landscape architects, architects, and urban planners to prioritize emotional well-being and create child-friendly, therapeutic landscapes in outdoor canal environments.

Keywords: *Visual greenery; Urban Canal environment; Emotional well-being; Teenagers; Low-income settlements*

1. Introduction

Since ancient times, civilizations like the Indus Valley, Nile Valley, Mohenjo Daro, Harappa, and Huang Ho have thrived near rivers because of their agricultural, transportation, and daily life needs (Lalor, Wolowski, and Roscher, 2015). Today, urban canals serve various purposes, including drainage, water supply, transportation, and aesthetic enhancement, contributing to sustainable urban environments (Kelvyn L. Richards, 2009). In Sri Lanka, particularly Colombo, urban planners have overlooked the potential of canals, using them primarily for drainage or neglecting them. Rapid urbanization and economic constraints have led to low-income settlements along these canals, often lacking basic amenities (Wijetunge, P.M., and Fernando, A.S., 2013). This poor environmental quality impacts children's well-being, with rising mental health issues among teenagers (Sri Lanka Health Ministry). Research indicates that visual experiences of nature improve emotional regulation, stress levels, and cognitive functioning (Johnson, D.W., Johnson, R.T., and Smith, K., 2014). However, access to green spaces is limited, especially for low-income children facing economic barriers (Silva and Tregidga, 2020). This study seeks to investigate whether limited exposure to visual greenery can enhance the emotional well-being of teenagers in low-income settlements and how visual aesthetics can foster child-friendly urban environments.

In Sri Lanka, canals mainly function as drainage systems and overlooked backyards, receiving minimal attention from the public and government sectors. Worldwide, urban canal environments face similar challenges, often addressed through regulations and guidelines. In Colombo, various ministries and the Urban Development Authority have initiated projects to revitalize urban canals, but questions remain about their effectiveness and maintenance. The aesthetic quality and accessibility of these spaces are often neglected, and the potential impact of visual greenery remains underexplored. Prior studies have focused mainly on the physical well-being of various age groups, with less attention on the emotional well-being of adolescents in economically disadvantaged communities, particularly from a landscape architecture perspective (Smith, J. K., and Brown, A. L., 2018). Most research has concentrated on canals in developed Western countries, highlighting a gap in the context of developing Southeast Asian countries like Sri Lanka.

This study aims to derive a collection of design considerations for creating child-friendly and therapeutic landscapes in outdoor green areas along the canal setting, focusing on landscape architecture and the emotional well-being of teenagers in low-income settlements. It also aims to evaluate teenager's emotional well-being in these areas based on the influence of outdoor greenery density, spatial distribution, blue-green visual integration, and their perceptions of green space types,

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vegetation types, plant diversity, and height variation along the canal waterfront. It seeks to identify the impact on self-satisfaction, optimism, autonomy, and vitality. By promoting awareness about emotional well-being and highlighting the benefits of incorporating mental health considerations into urban design, the study provides valuable insights for creating child-friendly urban areas. Through therapeutic landscape design, policymakers and stakeholders can use these insights to develop strategies for improving the mental well-being of teenagers living along Colombo's canal waterfront.

1.1. RESEARCH QUESTIONS

1. How can integrating visual quality (visual greenery and blue-green visual combination) of outdoor canal environments be beneficial in terms of the emotional well-being of teenagers in low-income settlements?
2. How do the visual quality design parameters and design aspects of outdoor green spaces in a canal environment (i.e., type of greenery, type of green spaces, amount of greenery, and blue-green combination) affect the emotional well-being and preferences of teenagers in low-income settlements?

2. Literature review

2.1. URBAN CANAL ENVIRONMENT

Canals have evolved from ancient irrigation systems in Egypt to vital components of transportation, trade, and industrial development. In Sri Lanka, canals date back to the Anuradhapura period for irrigation and transport, showcasing the country's advanced ancient civilization. The colonial era saw the construction of significant canals like the Hamilton and Dutch Canals for similar purposes. Today, canals globally and in Sri Lanka support transportation, irrigation, and tourism, maintaining their essential role in infrastructure and economic growth.

The term "canal" originates from the Old French word "Chanel," meaning "channel," and early canals, dating back to ancient Mesopotamia, have long facilitated trade, communication, and the connection of civilizations (National Oceanic and Atmospheric Administration (NOAA), 2018). Urban canals are manmade waterways designed for irrigation, drainage, navigation, or other purposes within urban areas, playing a crucial role in city development and providing services like water supply, drainage, transport, and recreation (United Nations, 2018).

A canal waterfront is a space alongside a canal designed for commercial, residential, and recreational activities, fostering social interaction and benefiting mental health. The presence of water enhances well-being and community connection. Canal waterfronts are intentionally designed with parks, bike paths, and public areas to encourage social and recreational activities, boost local businesses, and attract tourists. Urban planning regulations in Sri Lanka include setbacks, such as reservations and buffer zones. Buffer zones serve as transitional spaces between developments and the surrounding environment. The Urban Development Authority recommends adhering to specific limits for drainage areas.

2.2. TEENAGER'S EMOTIONAL WELL-BEING

"Teenagers" referred to as adolescents, represent a distinct developmental stage in the human lifespan. This transitional phase typically encompasses individuals aged between 13 and 19 years when there is rapid growth and development of the body and brain, bridging the gap between childhood and adulthood (World Health Organization, 2021). Profound physical, cognitive, emotional, and social changes are characterized as teenagers navigate the complexities of identity formation, peer relationships, education, and the transition to independence. Teenagers experience emotional sensitivity to peer relationships, leading to fluctuations in self-esteem and well-being. The desire for acceptance can cause insecurity and anxiety, which puberty and hormonal changes further intensify (American Psychological Association, 2021). Dividing teenagers into age categories helps explore their evolving emotional experiences. Early Adolescence (13-15) involves emotional turbulence due to hormonal changes and social pressures. Mid-Adolescence (16-17) sees the development of emotional resilience with better coping skills and peer support. Late Adolescence (ages 18-19) is marked by emotional maturity and stability (American Psychological Association, 2021).

Emotional well-being is crucial for teenagers, profoundly affecting their overall development, mental health, and life outcomes during the formative years of adolescence. Emotional differences between male and female teenagers are shaped by biology and socialization, with females often showing broader emotional responses (Kring and Gordon, 1998). Teenagers face challenges like peer pressure, academic demands, and identity exploration (Suldo et al., 2013).

2.3. VISUAL GREENERY

Visual greenery, encompassing trees, shrubs, grass, and foliage, transforms urban landscapes into vibrant, serene environments that provide both aesthetic appeal and significant health benefits (Kaplan, R., & Kaplan, s.,1989). Exposure to natural green environments has been associated with decreased mental fatigue, improved mood, and increased feelings of vitality (Hartig et al., 2014). Green spaces support fitness, reduce stress and anxiety, and boost cognitive development and creativity (Barton & Pretty, 2010). Integrating greenery into urban planning, such as courtyards, plant beds, and hanging pots, enhances aesthetics, supports biodiversity, and mitigates environmental challenges (Bratman et al., 2015). This approach improves air quality, reduces noise, and regulates temperatures, fostering community well-being and promoting environmentally responsible behavior (Goddard et al., 2010). Effective implementation involves using low-maintenance

native plants and sustainable practices, contributing to the overall sustainability and liveability of urban areas (Nowak et al., 2006).

2.4. VISUAL PERCEPTIONS OF HUMAN

Visual perception is a complex cognitive process where individuals interpret visual information through light reception and brain processing, affecting decision-making, emotions, and aesthetic appreciation (David & Wiesel, 1962). Influenced by factors like attention, memory, and cultural norms, it shapes how people prioritize visual information (Daniel & Chabris, 1999). Cognitive psychology, visual neuroscience, and perceptual psychology explore color vision, and depth perception, enhancing understanding of human interaction with the visual environment (Wertheimer, M.,1923).

Viewpoint, or the angle of observation, significantly impacts visual perception by determining the information available for processing, crucial for object recognition and scene interpretation (Rock & Palmer, 1990). Perceptual constancies and visual perspective cues help maintain stable perceptions despite changes in viewing angles, with optimal scenic views often positioned at an eye level of 5.5 to 6 feet above the ground (Palmer, 1999).

The timing of visual stimuli affects emotional well-being, with natural daylight, especially in the morning, improving mood, and alertness, and reducing depression symptoms by regulating circadian rhythms and serotonin production (Viola et al., 2008). Depth perception relies on cues like binocular disparity and linear perspective, with atmospheric effects and motion parallax aiding in gauging distances (David & Wiesel, 1962). The green ratio, which measures the proportion of green space, enhances visual appeal and emotional well-being, with low-density areas aiming for at least 20% green cover and high-density areas exceeding 30% (Beatley.T, 2011). High greenery ratios reduce stress, restore attention, and create relaxing environments (Ulrich, 1986).

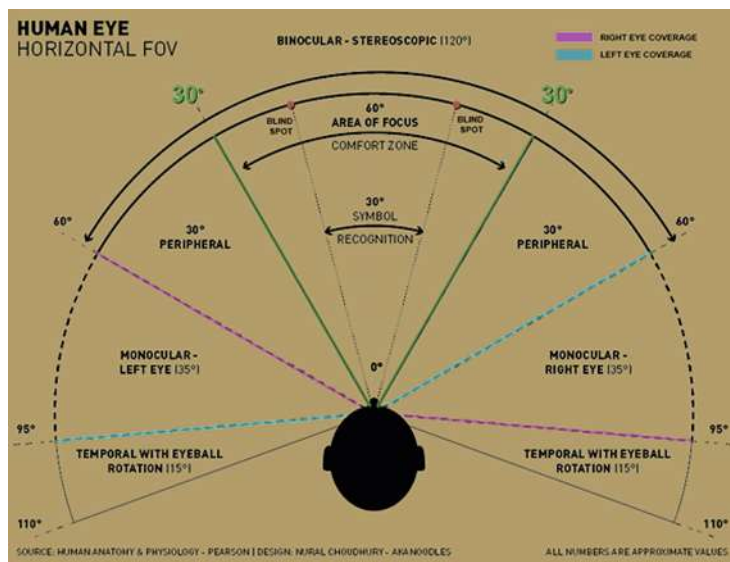


Figure 1: Human eye horizontal angle of vision
Source: Human Anatomy & psychology- person

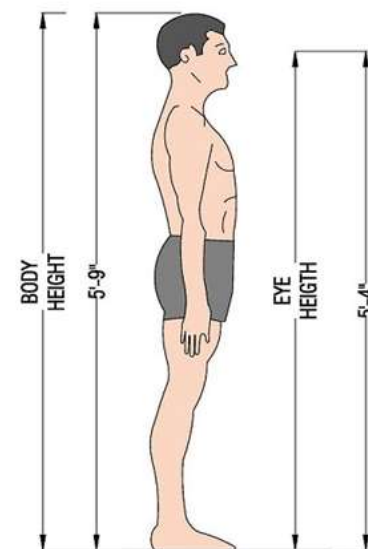


Figure 2: visual comfort height
Source: gharpedia.com

2.5. BLUE-GREEN VISUAL INTEGRATION

"Blue-green integration" combines blue and green elements in visual compositions, landscapes, or built environments to create aesthetically pleasing and emotionally engaging spaces. Drawing from color psychology, blue evokes calmness and tranquility, while green is linked to nature, growth, and renewal, promoting well-being. In urban planning and landscape architecture, this concept includes incorporating water features like ponds and lakes within green spaces such as parks and gardens, enhancing aesthetic appeal, and providing opportunities for relaxation and reflection (Ulrich, 1986). By blending these colors, designers create visually striking environments conducive to positive experiences.

Blue is associated with calmness and relaxation, helping teenagers manage stress and anxiety (Eiseman, 2000). Green associated with nature and growth, evokes feelings of freshness and vitality, aligning with Edward O. Wilson's biophilia theory that humans have an innate affinity for nature (Wilson, 1984). Integrating blue and green follows the Gestalt psychology principle of harmony, creating a pleasant and emotionally satisfying experience (Rock & Palmer, 1990). This combination fosters emotional equilibrium in teenagers, aiding in managing the emotional challenges of adolescence.

2.6. LOW-INCOME SETTLEMENTS

Low-income settlements are characterized by inadequate housing, high population density, poor sanitation, and limited access to essential services. Such conditions negatively impact physical and mental health, as residents often lack access to

clean water, healthcare, and education. Community-driven interventions, involving health, educational, and infrastructure improvements, can enhance outcomes in these areas (Patel et al., 2015). In Sri Lanka, the Department of Census and Statistics classifies income groups by monthly income, with low-income households earning up to LKR 29,999 (approximately USD 155).

Low-income settlements face multiple vulnerabilities: health vulnerability; economic vulnerability, educational vulnerability, and social vulnerability (Baum et al., 2015).



Figure 3: Low income settlements children and canal waterfront
 Source: [https:// data:image/jpg](https://data:image/jpg).

2.7. OUTCOME OF THE LITERATURE REVIEW

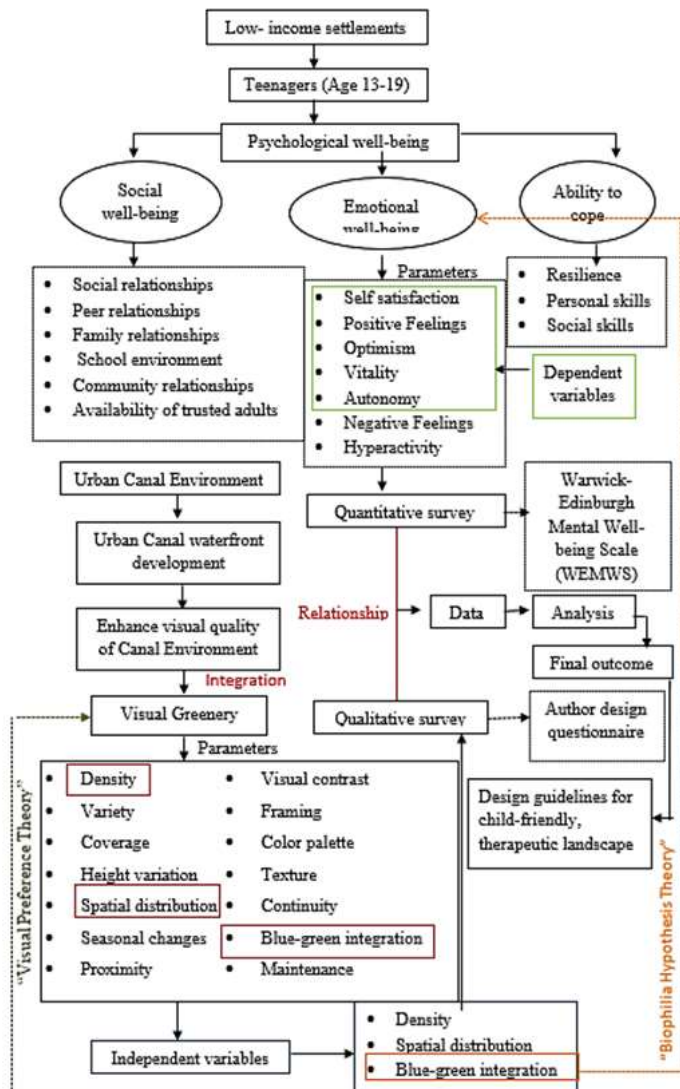


Figure 4: Outcome of the literature review
 Source: Compiled by author

3. Theoretical framework and research methodology

The visual preference theory suggests that people universally favor natural, green spaces due to a biophilic instinct (Kaplan & Kaplan, 1989). Studies confirm that greenery positively affects mental well-being by reducing stress and boosting mood (Berto, 2014). Both the theory and Edward O. Wilson's Biophilia Hypothesis support "blue-green integration", the combination of green and blue elements (e.g., water and vegetation) which enhances tranquility, relaxation, and a sense of connection to nature, fulfilling our innate affinity for natural surroundings.

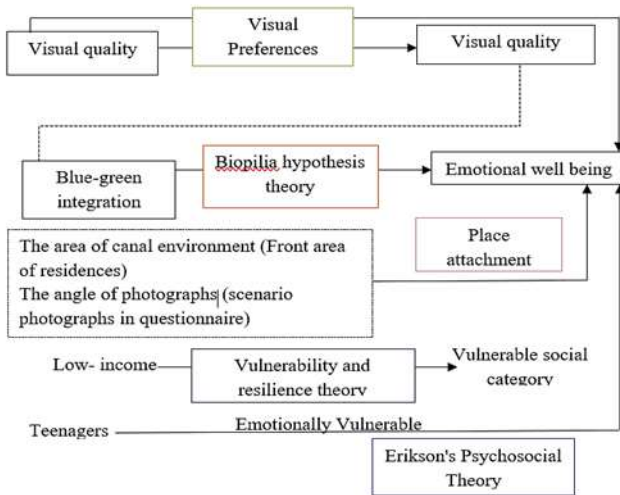


Figure 5: Theoretical Framework
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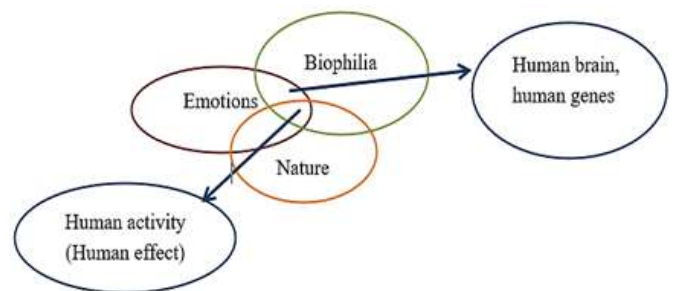


Figure 6: The connection of emotion, biophilia, and nature
Source: D.A.Halim, education for sustainable development (2019)

3.1. RESEARCH METHODOLOGY

The research would begin with a qualitative survey to gather demographic and environmental data (e.g., green density, blue-green integration, vegetation type) from teenagers in low-income settlements. Following this, a quantitative study would use the WEMWBS scale to assess hedonic and eudaimonic well-being related to visual greenery in an outdoor canal setting. A parental questionnaire would help validate findings and offer additional insights. The study, centered on the Kirulapone canal, would involve 40 teenagers (13-19 years old) from low-income areas who would evaluate five virtual 3D greenery scenarios over three days, with responses recorded via a Likert scale.

3.1.1 Case Study Selection Procedure

When selecting the case study participants consider the low-income residential distribution, green distribution, and related theories. According to the low-income distribution map, most of the low-income settlement distribution can be seen in this part of the canal in Colombo. The vegetation distribution in this area shows a low density of plant cover.

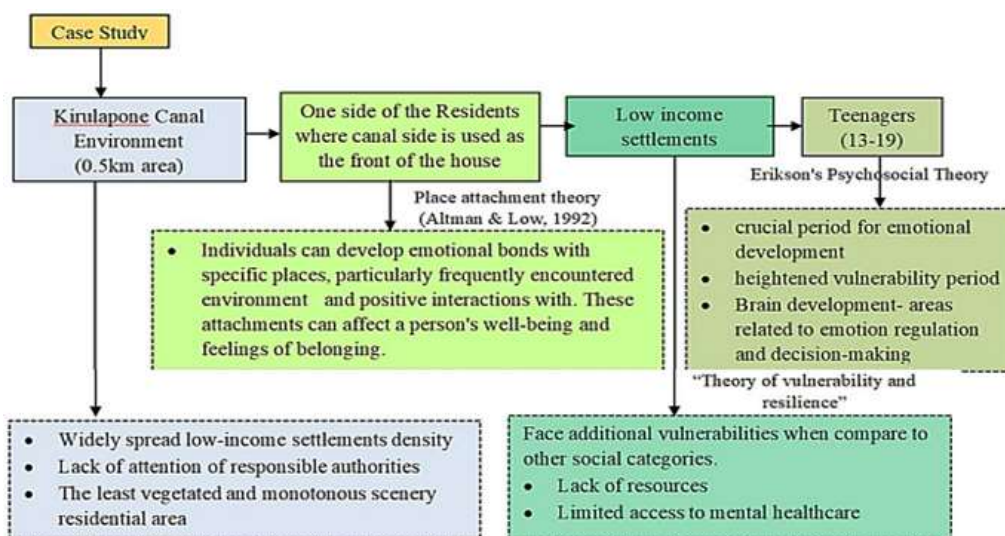


Figure 7: Case study selection criteria
Source: Compiled by author

Table 1: Research methodology
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Research question/ Objective	Data required	Data collection method	Data collection instrument	Data analysis method
Evaluate the teenager's emotional well-being, affects according to the visual of outdoor greenery density and spatial distribution	<u>Hedonic well-being</u> 1.Positive Feelings 2.Optimism	Structured survey questionnaire (For 40 teenagers in low-income settlements along the canal waterfront)	Warwick-Edinburgh Mental Well-being scale (WEMWBS) (questionnaire1/ section2)	Comparative analysis, Words analysis, Visual analysis Discussion
To evaluate the teenager's emotional well-being affects regarding the blue-green visual integration with outdoor canal environment	<u>Eudemonic well-being</u> 3.Self satisfaction 4.Vitality 5.Autonomy			
To identify teenager's perception regarding the green space type, vegetation type, plant diversity, height variation integrated with outdoor canal environment.	Teenagers perceptions, responses and suggestions	Structured survey questionnaire (For 40 teenagers in low-income settlements along the canal waterfront)	Personalized questionnaire (questionnaire 1/ section 3)	Manual analysis, Word analysis, Visual analysis, Comparative analysis, Discussion

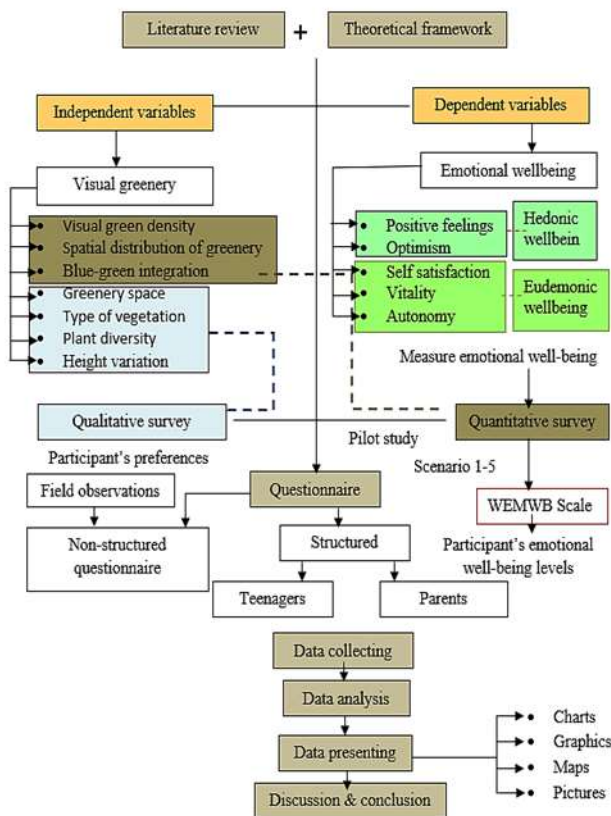


Figure 8: Method of study
Source: Compiled by author

4. Case studies, findings, and data analysis

4.1. CASE STUDY

The Kirulapone canal, within the residential and commercial area of the metro Colombo region, is among the highly contaminated urban waterways. While this drainage canal helps to prevent urban flooding in Colombo, it has undesirable characteristics. These issues stem from the negligent wastewater disposal practices of residents, leading to an enrichment of nutrients in the surrounding surface water ecosystems.



Figure 9: Kirulapone canal area
Source: Google earth



Figure 10: Kirulapone canal area
Source: Compiled by author

4.2. DATA ANALYSIS



Figure 11: Scenario A- Continuous planting- High green density with water scenario
Source: Compiled by author



Figure 12: Scenario B- Continuous planting- Low green density with water scenario
Source: Compiled by author



Figure 13: Scenario C- Patch planting- High green density with water scenario
Source: Compiled by author



Figure 14: Scenario D- Patch planting- Low green density with water scenario
Source: Compiled by author

4.2.1 Emotional well-being with relation to density of greenery

Continuous vegetation distribution

The study found that incorporating even low-density green spaces with continuous distribution in the canal area significantly enhanced emotional well-being, with 52.5% of participants moving from low or moderate to high or very high

well-being levels. Over 45% of those initially reporting low levels of emotional well-being improved, highlighting that a high green cover ratio with continuous distribution greatly enhances teenagers' emotional well-being.

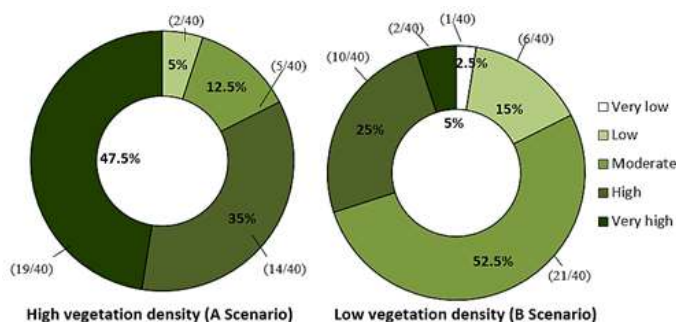


Figure 15: Percentage of participants regarding their emotional well-being level with relation to low and high greenery conditions in continuous vegetation distribution

Source: Compiled by author

Patch vegetation distribution

Compared to continuous green distribution, scenarios C and D show a decrease in emotional well-being, with an increase in low ratings which indicates that continuous greenery positively impacts teenagers' emotional well-being. The patch distribution and lower vegetation density reduce emotional well-being, yet even a high-density greenery patch (scenario C) performs better than a low-density continuous green scenario (B), reinforcing the importance of both greenery density and distribution patterns.

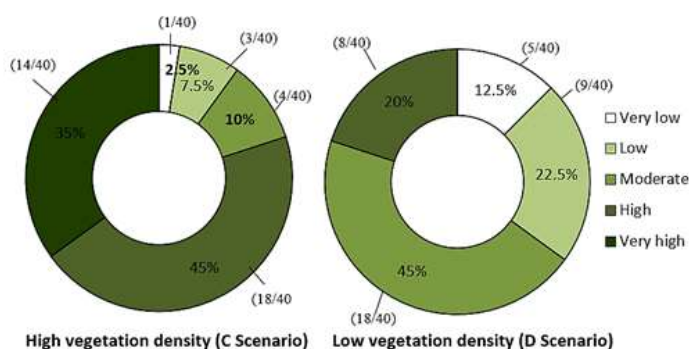


Figure 16: Percentage of participants regarding their emotional well-being level with relation to low and high greenery conditions in patch vegetation distribution

Source: Compiled by author

4.2.2 Emotional well-being with Relation to the distribution of greenery

High vegetation density (Scenario A & Scenario C)

The study found that continuous green distribution with high greenery levels significantly enhanced emotional well-being, increasing the proportion of participants in the very high emotional well-being category. Although patch distribution had some students with low emotional well-being (2.5%), green density was a more influential variable in teenagers' emotional well-being than distribution patterns.

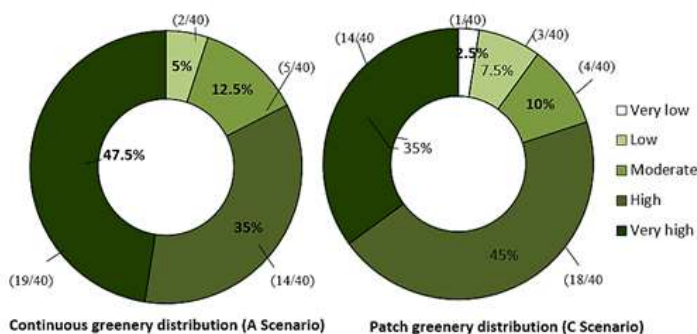


Figure 17: Percentage of participants regarding their emotional well-being level with relation to continuous and patch green distribution scenario in high vegetation condition

Source: Compiled by author

Low vegetation density (Scenario A & Scenario C)

Patch distribution of participants in low greenery conditions significantly decreases their emotional well-being, with 17.5% experiencing very low and low levels and 10% and 7% experiencing low well-being, highlighting the negative impact of patch distribution rather than a continuous pattern.

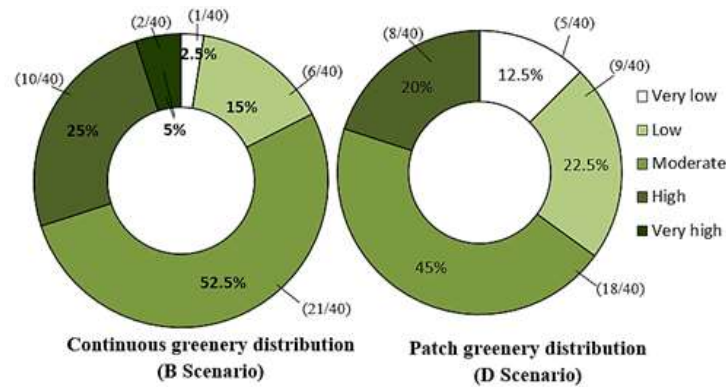


Figure 18: Percentage of participants regarding their emotional well-being level with relation to continuous and patch green distribution scenario in low vegetation condition

Source: Compiled by author

4.2.3 Water without vegetation (Control condition)

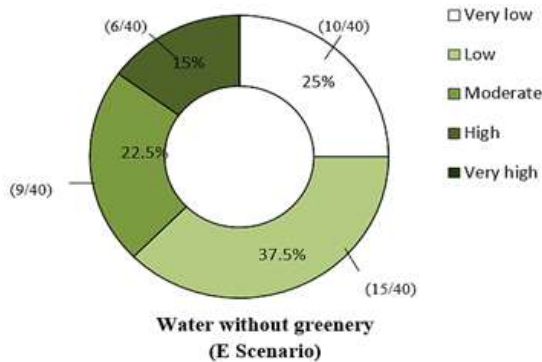


Figure 19: Percentage of participants regarding their emotional well-being level with relation to blue without green scenario

Source: Compiled by author



Figure 20: Control condition

Source: Compiled by author

In the control condition, featuring the existing canal space without greenery, participants reported low emotional well-being, with 37.5% experiencing low and 25% having very low emotional well-being. These findings suggest a significant lack of enjoyment in non-green environments and may indicate a risk of depression among participants.

4.3. OVERALL RESULTS AND DISCUSSION

This study found that variations in outdoor green coverage ratio (GCR) (20% vs. 30%) consistently enhanced participants' emotional well-being, even when the plant distribution pattern remained unchanged. This differs from Han's (2009) findings, where lower outdoor GCRs (3.0% and 8.83%) did not significantly impact participants' psychological perceptions, potentially due to the minimal GCR differences and lower visibility of changes. Han's results may also have been influenced by environmental conditions like temperature and humidity, factors not accounted for in this study. Ultimately, this study highlighted that the green coverage ratio, distribution patterns, and blue-green visual combination of plants significantly affect emotional well-being when other conditions are constant. The results show that any level of greenery, (Scenario A, B, C, D) improved participants' emotional well-being compared to the blue-without-green condition (E), which has no greenery. This aligns with previous studies (Han, 2009; Shibata & Suzuki, 2002), which found that even a few outdoor plants positively impact overall well-being.

The study found that continuous outdoor greenery distribution at a 16.5% green coverage ratio (GCR) maximized psychological well-being, with participants reporting high satisfaction, optimism, vitality, and autonomy, each scoring above 80%. High greenery (30% GCR) in canal spaces was especially effective in enhancing emotional well-being compared to lower greenery levels. In low greenery scenarios (5.5% GCR), continuous distribution improved well-being more than patch distribution, however, close distances (3-3.54m) and low GCR negatively impacted Eudaemonic well-being, particularly reducing vitality and autonomy. Patch-distributed low greenery resulted in the lowest well-being across all measures.

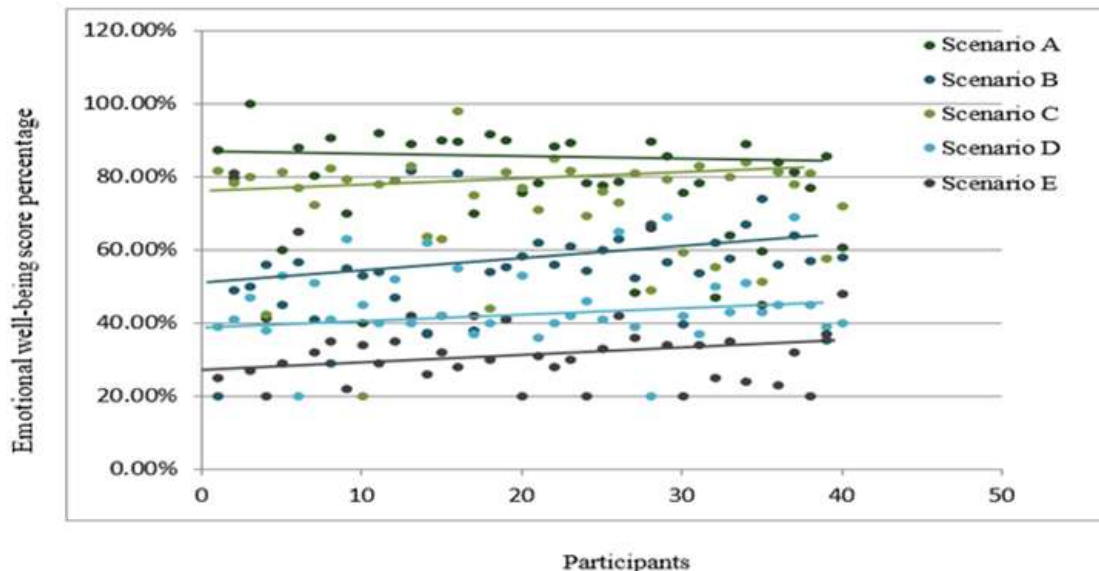


Figure 21: Emotional well-being score percentage of teenagers in all five scenarios
 Source: Compiled by author

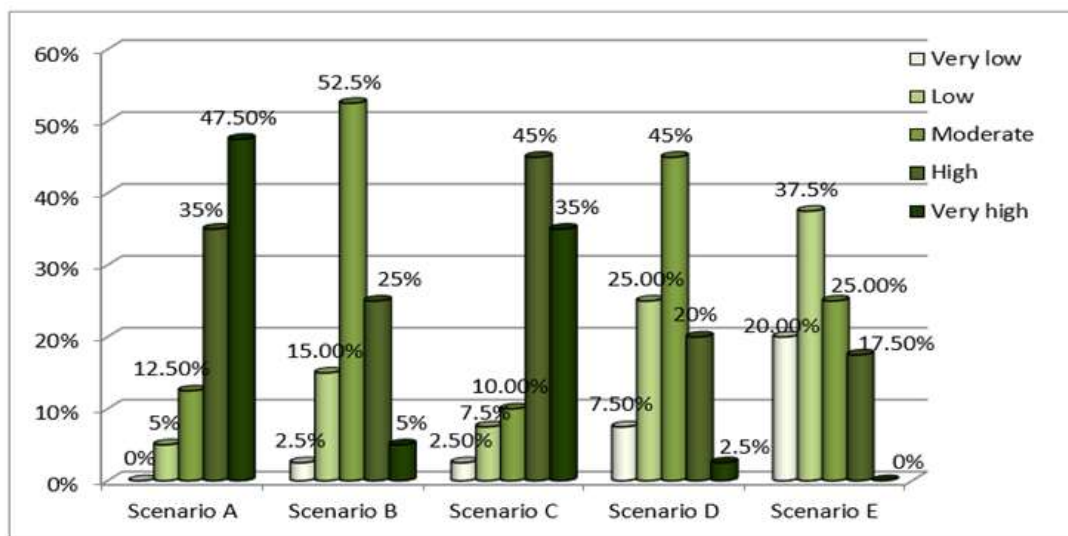


Figure 22: Emotional well-being level percentage of teenagers in all five scenarios
 Source: Compiled by author

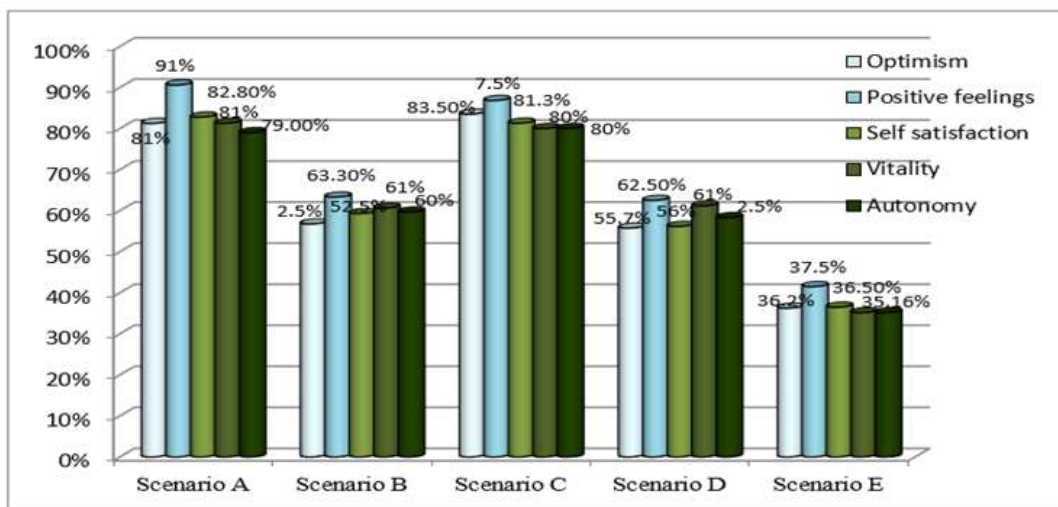


Figure 23: Mean average score percentage for WEMWS parameters in five scenarios
 Source: Compiled by author

4. Conclusion

This study is the first to investigate the emotional well-being of teenagers in low-income settlements, examining their satisfaction, positive affect, optimism, vitality, and autonomy levels regarding visual green cover ratios, greenery distribution patterns, and Blue-Green visual combinations in outdoor environments. Using a 3D simulated experimental setup, five indoor scenarios were tested with different green cover ratios and distribution patterns: low green cover (20% GCR), high green cover (30% GCR), continuous vegetation distribution, patch vegetation distribution, and Blue-Green visual combinations. Findings revealed that high outdoor visual greenery with continuous distribution provided the best emotional well-being benefits, offering high satisfaction, positive feelings, personal control, and resilience, enhancing both hedonic and eudaemonic well-being. Even low greenery was better than none, especially in a continuous distribution. The worst scenario was water without greenery, delivering the lowest well-being and satisfaction levels. Both male and female teenagers were similarly affected by these variables, though high greenery conditions had a slightly more positive effect on males. Most participants preferred outdoor plant pots for their ease of maintenance and natural appearance, though some favored courtyards or plant beds with lower greenery. These findings suggest that designing outdoor green spaces should prioritize emotional well-being alongside aesthetic considerations in landscape architecture.

This study initiates research into how teenagers' emotional well-being varies with outdoor visual greenery amounts, distribution patterns, and Blue-Green visual combinations in canal environments, investigating five scenarios to uncover basic relationships. Future research should explore comprehensive patterns, minimum and maximum values of these variables, and their connections to achieve optimal emotional well-being in various outdoor settings. Additionally, examining the objective effects of outdoor plants on physical conditions like temperature, humidity, and air quality is recommended, as these factors can indirectly impact teenagers' psychological well-being. Since this study did not account for these physical conditions, future research should investigate how they interact with visual green space design parameters to affect emotional well-being. Moreover, future studies could also examine the impact of outdoor visual green spaces on the learning performance of teenagers in low-income settlements and how these performances are influenced by green space design parameters.

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